June, 1976 Price, $2.00

In Honor of Philip Morrison:
Articles by Hans Bethe, Frank Drake,
Martin Gardner, Jerome Lettvin,
Frank Oppenheimer, and Cyril Smith
Cover by Charles Eames

Technology Review

Edited at the Massachusetts Institute of Technology

technology
review
Published by MIT

SPECIAL REDUCED ALUMNI RATES

TWELFTH ANNUAL TOUR PROGRAM—1976

1976 marks the twelfth year of operation for this unique program of tours, which visits some of the world's most fascinating areas and which is offered only to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Pennsylvania, Columbia, Dartmouth, and certain other distinguished universities and to members of their families. The tours are designed to take advantage of special reduced fares offered by leading scheduled airlines, fares which are usually available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 over normal air fares. In addition, special rates have been obtained from hotels and sightseeing companies.

The tour program is consciously designed for persons who normally prefer to travel independently and covers areas where such persons will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine as much as possible the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest. Each tour uses the best hotel available in every city, and hotel reservations are made as much as two years in advance in order to ensure the finest in accommodations. The hotels are listed by name in each tour brochure, together with a detailed day-by-day description of the tour itinerary.

The unusual nature and background of the participants, the nature of the tour planning, and the quality of the arrangements make this a unique tour program which stands apart from the standard commercial tour offered to the general public. Inquiries for further details are invited.

AEGEAN ADVENTURE

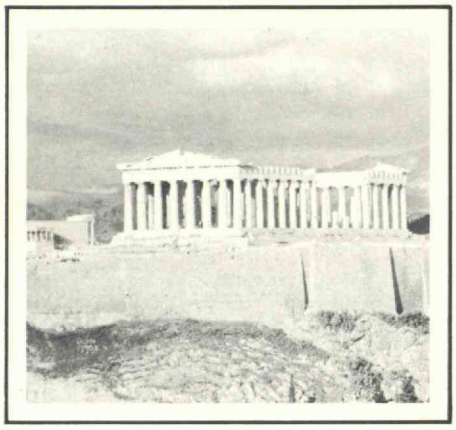
23 DAYS $2050

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean and Asia Minor, including not only the major cities but also the less accessible sites of ancient cities, together with the beautiful islands of the Aegean Sea. Visiting Istanbul, Troy, Pergamum, Sardis, Ephesus and Izmir (Smyrna) in Turkey, Athens, Corinth, Mycenae, Epidauros, Nauplion, Olympia and Delphi on the mainland of Greece, and the islands of Crete, Rhodes, Mykonos, Patmos and Santorini in the Aegean. Total cost is $2050 from New York. Departures in April, May, July, August, September and October 1976. (Additional air fare for departures in July and August.)

SOUTH AMERICA

28 DAYS $2265

From the towering peaks of the Andes to the south Atlantic beaches of Rio de Janeiro, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America. Visiting Bogota, Quito, Lima, Cuzco, Machu Picchu, La Paz, Lake Titicaca, Buenos Aires, the Argentine Lake District at Bariloche, the Iguassu Falls, Sao Paulo, Brasilia, and Rio de Janeiro. Total cost is



$2265 from Miami, $2300 from New York, with special rates from other cities. Departures in January, February, March, April, May, July, September, October and November, 1976.

THE ORIENT

29 DAYS $2450

A magnificent tour which unfolds the splendor and fascination of the Far East at a comfortable and realistic pace. Visiting Tokyo, the Fuji-Hakone National Park, Kyoto, Nara, Nikko and Kamakura in Japan, as well as the glittering temples and palaces of Bangkok, the metropolis of Singapore, the fabled island of Bali, and the unforgettable beauty of Hong Kong. Optional visits to the ancient temples of Jogjakarta in Java and the art treasures in the Palace Museum of Taipei. Total cost is $2450 from California with special rates from other points. Departures in March, April, May, June, July, September, October and November, 1976 (extra air fare for departures July through October).

MOGHUL ADVENTURE

29 DAYS $2395

An unusual opportunity to view the magnificent attractions of India and the splendors of ancient Persia, together with the once-forbidden Kingdom of Nepal. Visiting Delhi, Kashmir (Bombay during January through March), Banaras, Khajuraho, Agra, Jaipur and Udaipur in India, the fascinating city of Kathmandu in Nepal, and Teheran, Isfahan and the palaces of Darius and Xerxes at Persepolis in Iran. Total cost is $2395 from New York. Departures in January, February, March, August, September, October and November, 1976.

THE SOUTH PACIFIC

29 DAYS $2895

An exceptional tour of Australia and New Zealand, from Maori villages, boiling geysers, ski plane flights and jet boat rides to sheep ranches, penguins, the real Australian "Outback," and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand and Canberra, Melbourne, Alice Springs, Cairns and Sydney in Australia, with optional visits to Fiji and Tahiti. Total cost is $2895 from California. Departures in January, February, March, April, June, July, September, October and November 1976.

EAST AFRICA

23 DAYS $2165

The excitement of Africa's wildlife and the magnificence of the African landscape in an unforgettable luxury safari. Visiting Lake Naivasha, Lake Nakuru, Samburu Reserve, Treetops (Aberdare National Park), Masai-Mara Reserve, the Serengeti Plains, Ngorongoro Crater, Nairobi and Mombasa. Total cost is $2165 from New York. Optional visits are available to the Amboseli and Tsavo National Parks, the Victoria Falls, on the mighty Zambezi River between Zambia and Rhodesia, to Zanzibar, and to the historic attractions of Ethiopia. Departures in January, February, March, May, June, July, August, September, October, November and December 1976.

MEDITERRANEAN ODYSSEY

22 DAYS $1745

A unique and highly unusual tour offering a wealth of treasures in the region of the Mediterranean: Tunisia, with the ruins of Carthage and many other Roman cities as well as lovely beaches, historic Arab towns and desert oases; the beautiful Dalmatian Coast of Yugoslavia, with its fascinating and medieval cities; and the 17th and 18th century splendor of Malta. Visiting Tunis, Carthage, Dougga, Sousse, Monastir, El Djem, Gabes, Djerba, Tozeur, Sbeitla, Kairouan and Thuburbo Majus in Tunisia; Split, Trogir, Sarajevo and Dubrovnik on the Dalmatian Coast of Yugoslavia, and Valletta and Mdina in Malta. Total cost is $1745 from New York. Departures in March, April, May, June, July, September and October, 1976 (additional air fare for departures in June and July).

* * *

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes.

Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1977 are also available.

For Full Details Contact:

ALUMNI FLIGHTS ABROAD
White Plains Plaza
One North Broadway
White Plains, N.Y. 10601

Edited at the
Massachusetts Institute of Technology

Volume 78, Number 7
June, 1976

Technology Review

Technology Review, Reg. U.S. Patent Office is published eight times each year (in October/November, December, January, February, March/April, May, June and July/August) at the Massachusetts Institute of Technology: two special editions are provided for graduate (pp. 1-96) and undergraduate (pp. 1-120) alumni of M.I.T. Entire contents copyright 1976 by the Alumni Association of the Massachusetts Institute of Technology. Technology Review is printed by The Lane Press, Inc., Burlington, Vt. Second class postage paid at Boston, Mass., and at additional mailing offices.

Inquiries regarding editorial contents, subscriptions and advertising should be addressed to: Technology Review, Room E19-430, Massachusetts Institute of Technology, Cambridge, Mass. 02139. Telephone area code (617) 253-4872.

Price: $2 per copy. Subscriptions: in the U.S., Canada, and Mexico — $15 one year, $24 two years, $32 three years; overseas $23 one year, $38 two years, $50 three years. Please allow three weeks for changes of address and give both old and new addresses in all requests.

Technology Review is represented for advertising by: Littell-Murray-Barnhill, Inc., 60 E. 42nd Street, New York, N.Y., 10017, telephone (212) 867-3660; Cemcon, 4 N. Elmhurst Street, Prospect Heights, Ill., telephone (312) 398-0794; Zander, Coughlin and Thompson, 5478 Wilshire Boulevard, Los Angeles, Calif., 90036, telephone (213) 938-0111 and 22 Battery Street, San Francisco, Calif., 94111, telephone (415) 398-4444.

Publisher
James A. Champy

Board of Editors
John I. Mattill *(Editor)*, Dennis L. Meredith, Michael Feirtag, Sara Jane Neustadtl, Marjorie Lyon, Deborah McGill, Susanne Fairclough

Production
Kathleen B. Sayre

Advertising
Richard F. Wright

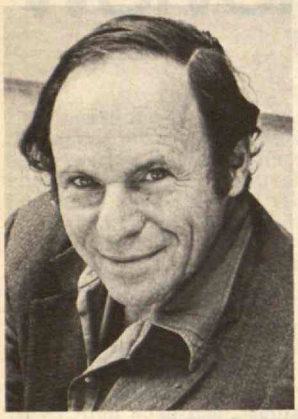
Circulation
Katherine A. Potter

Subscription Service
Dorothy R. Finnerty

Articles

Departments

The First Line



In Honor of Philip Morrison

This issue of *Technology Review* is unique in our history in both its purpose and origin. The purpose is to honor Philip Morrison, Institute Professor at M.I.T., on his 60th birthday, for reasons described by Professor Victor Weisskopf on page 21. The origin lies with Professor Kenneth Brecher, a student and colleague of Professor Morrison, and Phylis Morrison, his wife, who proposed this form of tribute to the Editors of the *Review* — thinking, no doubt, of Philip Morrison's remarkable contributions in the magazine format to *Scientific American*. Together they suggested the contributors — all friends of Professor Morrison — and they arranged for each author's contribution (including the cover photograph). Professor Brecher and Mrs. Morrison are in fact the Guest Editors of this issue; the Editors as well as our readers are deeply indebted. — *J.M.*

Letters

Cool Cash

George C. Newton, Jr.'s return-on-investment evaluation of the benefits due to appliance design enhancements (*"Energy and the Refrigerator," January, pp. 56-63*) overlooks one factor which makes such benefits more attractive. For most individuals, a dollar saved is worth more than a dollar earned. Return on investment in the form of savings is tax-free!

Richard A. Butterworth
Marblehead, Mass.

Dr. Newton replies:

If tax considerations were recognized explicitly, an individual in the 30 per cent bracket with a 15.7 per cent tax-free return has the equivalent of a 22.4 per cent return on investment before taxes. This is in the range of the return before taxes (20 to 25 per cent) that many businesses use as a guide for investment decisions. It may be argued that the individual investing in a refrigerator assumes less risk than a business which adds to its plant, and therefore should be content with a lower rate of return.

Sense in Recycling

I am alarmed by the suggestions and implications in "Why Not More Recycling?" (*January, pp. 22-23*), among them:

— That the use of virgin fiber to make paper products is irresponsible;

— That the paper industry is not very bright and is ignoring the long-term advantages of recycled fibers;

— That the waste system analytical model includes all important factors and interrelationships;

— That all virgin fiber comes from pulpwood;

— That government intervention and a 50 per cent tax on products made from virgin fiber will solve the problem.

I was pleased to note that the following article (*"Resources: The Future Need Not Be So Different from the Past," pp. 23-24*) stated: "The lesson is clear — no government can decide how resources are to be allocated to a free industrial system without jeopardizing that system's freedom."

J. L. McClellan
Wright City, Okla.

Mr. McClellan is Vice-President, Oklahoma Region, for Weyerhaeuser Co. — Ed.

The Profit Motive in Practice

Kenneth E. Boulding writes in awe-filled tones of the underpinnings of modern economic practices to be found in Adam Smith's *The Wealth of Nations* (*"Fruitful Inconsistencies: The Legacy of Adam Smith," March/April, pp. 3, 12*).

When I took that one course in economics, either no mention was made, or insufficient emphasis was given to the contribution of that great thinker. It was not until much later that I learned such a person had lived. It is interesting to note the frequency with which Adam Smith's name is associated with the concept of a free market.

The recent raising of voices in the business community in defense of the free enterprise system calls for us all to review the principles documented in *The Wealth of Nations*. Certainly the free enterprise system should be defended when it is attacked. There is no question that it is under attack today. However, as with attorneys at the bar of justice, shouldn't the defenders come to the defense with clean hands? In far too many markets today, administered prices are the prevailing manner of establishing value in the marketplace. It is true that this could be a starting point for the trading process. However, too frequently the product is left to deteriorate rather than sold below cost as demanded by the laws of supply and demand.

I'm afraid that much of the talk we hear about free enterprise involves very nearly an academic application of the principles of the free market called to our attention by Adam Smith. The overall effect is one of maintaining the image of practicing the principles of free markets, rather than defending the actual use of the marketplace. The justification is frequently given that consumer confidence in business must be maintained.

Too often, profit is thought an end in itself. In the rush to maximize profits, we forget about the service that is the implicit contractual obligation of the marketplace. The profitability of a product is not related to satisfying consumer needs but rather to whether we can "earn" the commission by "selling" the hardware to the customer. Again, we forget that the hardware is supposed to render the service the designer intended. So the producer is reluctant to make adjustments for merchandise that does not serve as intended, and he waits until the government or the courts set a precedent for him to go by. Furthermore, the S.E.C. may prosecute, or the stockholders may sue the management if they feel the company volunteered to correct a product deficiency — reducing profits by expenditures for the customer when no legal requirement existed.

We do appreciate Dr. Boulding's effort to remind us of the breadth of Adam Smith's thinking as displayed in *The Wealth of Nations*. However, as with most philosophical teaching, the complexities that may be and are implied in so simple a statement of truths cause many ambiguities and anomalies in the application of those truths. And then, many of the traditional activities of the marketplace are continued after the relevant truths of the natural law become known. Not all of the traditional practices cause any divergence from principle because the experience of history also produces truth. Nevertheless, the perfect knowledge of how to apply the natural law is much beyond our ability to foresee. So we must stumble along in our bumbling way, learning painfully at times, and joyfully at times, but learning as time passes.

E. J. T. Lima
Forest City, N.C.

So What?

"The Universe: An Open or Closed Case?" by Irwin I. Shapiro (*December, pp. 64-71*) is very interesting, but the question is, What difference does it make?

According to the Standard Model, the cosmos is analogous to a horse race, started by the "big bang," which sent the galaxies racing outward in all directions, so the faster ones have gone farther, and we find their distances proportional to

their speeds.

According to Mach's principle, the far-flung frontiers of the universe have local effects, influencing terrestrial affairs.

According to Einstein's theories, which quantify Mach's principle, the local effects must be totally metric (i.e. entirely gravitational), because natural laws allow no other manifestation of Mach's principle.

A metric analysis indicates tidal forces proportional to H_0^2, with the proportionality factor positive for an open universe, and negative for a closed one.

Thus, if the universe is open, then there are expansive tidal forces tending to pull everything apart, but their magnitude is minimal, so the effect is inconsequential for practical purposes.

On the other hand, if the universe is closed, then there are contractive tidal forces tending to compress everything, but again minimal at this stage. Later, however, when the cosmos contracts, the compressive tidal force will finally become maximal, and crush everything into a black hole.

The question remains: What's the difference?

Kenneth J. Epstein
Chicago, Ill.

Isn't It Organic?

Considerable interest by the scientific community is focused on Loch Ness, and many otherwise fine and respected scientists may be looking a little foolish before it is over (*"Search for the Loch Ness Monster," March/April, pp. 25-40*).

However, some factual information must be considered:

— "Monster" sightings and attendant hissing sounds have been reported for over 1,000 years.

— The cameras and pictures are not lying. They do record large objects moving in the dark waters of Loch Ness.

— The Loch Ness area of Scotland has a great need for tourist dollars, and is an interesting place to visit.

The waters of Loch Ness are very high in organic (vegetable) matter. Visibility, even at close range, is limited. The organic matter settles out on the bottom of the lake, where it slowly solidifies, forming mats of peat-like material which becomes quite dense and tough.

Methane gas enters the picture, either escaping slowly from under the lake or as a product of the layers of decaying organic matter on the lake bottom. The gas accumulates between layered mats of the organic material, buoying up and tearing loose large, irregular sections of these mats and forming large, balloon-like "monsters," which rise slowly to the surface.

When the "monster" reaches the surface, parts protrude from the water, causing it to capsize, often with a great commotion. It releases gas, which causes the

(Continued on p. 69)

Surely, that can't be the whole answer? Something's missing!

When you calculate the important personal investment you've made in your education, is this all the answer you want? You're **you**. And there's more to life than just "a job"—or should be.

What could you expect if you joined us? A quality of life that means the difference between "a job" and a way of living.

We design and manufacture complete electronic systems of various kinds for business, industry and government. It is our practice to hire very able people and then put them to work doing what they most like to do.

Because we are a large company, we offer a total career growth-potential that is as big as we are. And because we work in relatively small product-oriented divisions, your abilities and contributions are highly visible from the time you join us, with prompt recognition of superior performance.

Whether you work for us in California, New York, Ohio, South Carolina, Florida, Kansas or Delaware, you'll find yourself looking forward to coming to work in the morning. And your technology won't become obsolescent in 5 or 10 years, because, to remain a leader, we must continue to work on the leading edge of the current state of the art.

Professional involvement . . . continuing development as an engineer . . . an environment of individual responsibility that encourages new ideas and rewards initiative. These are good dividends on the personal investment you've already made on your education!

If you're not realizing them now, write:

Mr. Thomas A. Payne, Dept. TR-6
Corporate Executive &
Professional Recruitment
NCR Corporation
Dayton, Ohio 45479

An Equal Opportunity Employer

NCR

Know-how and the Price of Cheese

Technology/Society
by
Kenneth E. Boulding

As far as I can see, the negative character of entropy does very little harm in thermodynamics; a relatively simple algebra applies, and minus-minus is the same thing as plus. But in social systems, simple algebra does not work — one reason why the application of mathematics to the social sciences has been rather frustrating. Not doing harm is a very different thing from doing good. Thus it is important to get our signs right; negative thinking about positive concepts can get us into real trouble.

We see this especially as we try to expand the entropy concept beyond thermodynamics. An increase in entropy is the same thing as a decrease in potential, and in thermodynamics, potential is simply negative entropy. The general form of the Second Law is that if anything happens, it is because there is a potential for its happening and that after it happens, that potential has been used up.

We get into trouble, however, if we try to generalize the entropy concept too much. It seems much more consonant with ordinary speech to say that potential is used up rather than that entropy rises. The image of increasing wealth is much richer than that of diminishing poverty. It is very hard indeed to say what it is that diminishes when poverty is diminished. It is fairly easy to say what is increased when wealth is increased.

Intellectual Evolution

Thinking of entropy in terms of potential raises the possibility that potential can be recreated. We see this very clearly in genetic potential. A fertilized egg has enormous genetic potential. Given the right environment, it will realize its potential and produce the appropriate phenotype. As the process of realization takes place, however, the potential diminishes and eventually is exhausted in death. We could, I suppose, think of entropy in this case as the chance of death which rises throughout the history of the organism until death finally ensues. But this seems very inadequate against the extraordinary complexity of the process by which genetic potential is realized.

Furthermore, genetic potential is constantly recreated in new fertilized eggs (in the case of sexual reproduction) or in newly-split cells or organisms (in the case of asexual reproduction). This is possible because genetic potential is information, and information can be copied and replicated — as it is with DNA, which has been described as the world's first three-dimensional Xerox machine.

Evolution is a process in the realm of something that might be called "know-how." I rather like to use a good old Liverpool word for it, "nous," which also has good Greek ancestry. Nous or know-how implies a little more than Bell Telephone information, although information of that sort is undoubtedly its building blocks. The essence of evolution is the extraordinary property of know-how to replicate, recombine, mutate, and make new know-how. Phenotypes, including our own, are merely intermediate codings of the genetic structure. Samuel Butler said that the chicken is just an egg's idea for producing eggs, and in terms of biological evolution, humans have the same lowly status as a coder and carrier of genes.

Human genes, however, produced the human organism and the human brain, which produced human knowledge, which produced human artifacts, which produced social systems. Just as a fertilized egg has the potential for the organism it will produce, so Adam and Eve (whatever their names were) had the potential for agriculture and civilization, science, war, literature, art, and all that the human race has produced. Even though the potential in any particular fertilized egg is used up as it is realized, the overall genetic potential is recreated in new fertilized eggs.

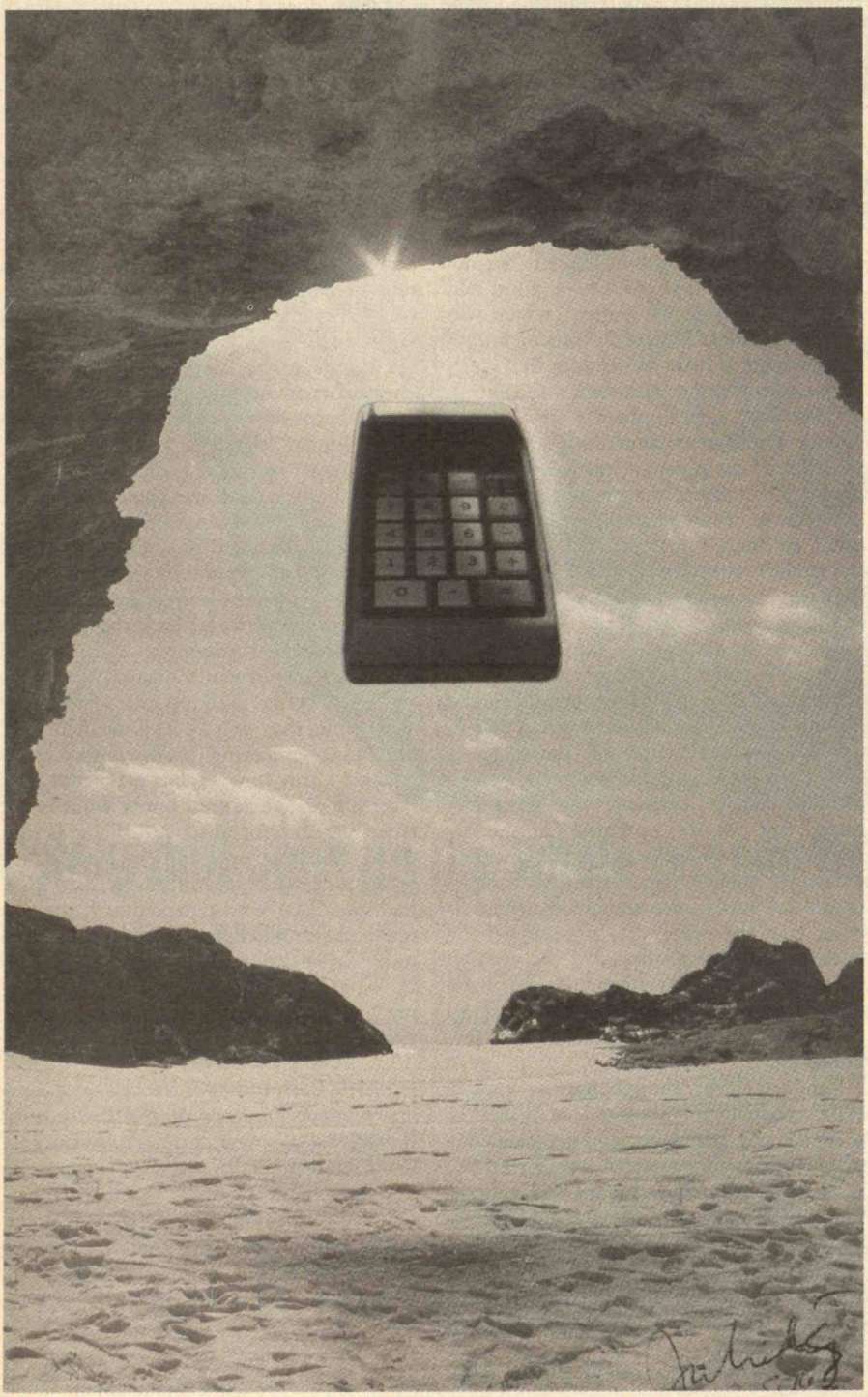
Similarly, even though human knowledge exhausts its potential as it makes societies, organizations, and artifacts, this potential is constantly recreated as knowledge transmitted from one generation to the next, and is enlarged by new learning. The law of social entropy is the constant tendency of social potential of all kinds to be used up. Social evolution is the constant tendency for social potential to be recreated.

One might remark, this is all very well, but what does it have to do with the price of cheese? The answer is, oddly enough, a great deal. The classical economists saw economic evolution (though they did not use that term) as a constant race between capital and population. When capital outstripped people, real income and real wages rose. As people outstripped capital, real income and real wages fell. This is simply a special case of a much more general principle, that human welfare is a race between growing social potential — properly disseminated and organized knowledge — and the constant tendency for things to be used up. The price of cheese or of anything else is what it is today because of where we are in this race. Human welfare is a function of the three great factors of production: not land, labor, and capital, but know-how, energy, and materials. Energy and materials tend to be used up. Only the rise of know-how can expand or restore them.

When the rise of know-how prompted the discovery of fossil fuel, the potential for the energy throughput of the social system increased enormously. Now fossil fuels are being used up. In a relatively short time, they will all be gone. The only hope for overcoming this dissipation is increased know-how — but even that may have limits. We cannot know what is not true; we cannot discover what is not there. The real price of cheese is much lower today than it would have been if we had not discovered petroleum. It may be much higher when petroleum is exhausted unless new knowledge and new know-how push back the constantly encroaching limits imposed by the social entropic processes.

Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado.

Home Economics: Good Uses for the Calculator



No one is buying slide rules any more, not even engineers. Retail stores are sending their slipsticks back to the manufacturers and replacing them with the electronic variety. In fact, one American family in four now owns an electronic calculator. Within five years, 90 per cent of the minicalculator market will be "programmables," analysts at Texas Instruments, Inc., predict. Even today, $1,000 "family computers" are advertised by mail-order companies located in such places as Bountiful, Utah. Reading the printout on the wall, I.B.M. has set up a new small products division to promote a $9,000 "portable" computer.

Now that the computer has finally reached the common man, perhaps it is time to think about its social impact.

Electronic Ignorance?

Storm clouds are already appearing over the nation's public schools. A number of educators have begun experimenting with calculators as a prop to help teach mathematics. Since calculators fascinate many students who find math intolerably dull otherwise, why not put them to good use? Organizations such as the National Council of Teachers of Mathematics have endorsed the idea.

On the other hand, many teachers and parents oppose the use of calculators, particularly in elementary grades. They argue that children may come to rely on calculators and never learn to add, subtract, multiply, and divide in their heads or with paper and pencil. Perhaps there is some warrant for that fear. According to Martin Gardner, *Scientific American*'s mathematical gamesman, the advent of the mechanical calculator meant the end of the math wizard, a breed of showman who could add, subtract, multiply, and divide large numbers in his head in seconds.

To assess the potential impact of calculators on students' arithmetic abilities, it is important to establish how effective traditional math teaching has been. A recent study concludes that a majority of Americans are "functionally illiterate" — unable to figure unit prices, comprehend written directions, balance a checkbook,

National Report
by
David F. Salisbury

and carry out other tasks demanded by modern society.

Why? I think most of us banish mathematics to a detached mental compartment which we open only with reluctance to sort out financial matters. If this is the case, what we need in order to benefit most from mathematics is to establish connections between the forms of the discipline and "real-world" problems.

According to Glenadine Gibb, Professor of Mathematics Education at the University of Texas at Austin, there are indications (though no proof) that students using calculators are more motivated than those who don't. But will using the calculator as an adjunct to traditional teaching ameliorate the problem of functional illiteracy?

There is a good chance that it won't. Anyone other than the professional mathematician who has attempted to use a calculator to solve commonplace problems has probably been frustrated. The story problems in high school algebra don't prepare one to figure out how much will be saved on fuel bills by increasing insulation. Necessary data is often unavailable or difficult to gather. Misunderstanding the uncertainties in measurements can produce severe errors despite eight-digit accuracy.

Practical Mathematics

What may be required to correct this situation is a complete inversion of the traditional approach to teaching mathematics. Today, the modus operandi is theory, example, theory, example — and the examples are designed to illustrate the theory, not its applications. Why not start instead with the practical situation which gave rise to the theory, and show how the theory was devised to meet a need? Take the evolution of mathematics itself as the pattern. Mathematics is rooted in barter and trade. The popularity of various types of trading cards among young children indicates innate interest in this sort of activity. Setting up a counting system and objects to exchange, allowing the children to trade, and then analyzing what happens could enhance skills of addition and subtraction as well as add relevance to basic drills.

At a fairly early stage, the calculator could play an integral part in such an approach. It would enable students to work out quickly problems which took bygone mathematicians years to solve. It would allow students to grapple with real problems, rather than storybook examples. Most important, such a method might help many more people to rely upon mathematical reasoning in their daily lives, and to appreciate the strengths and weaknesses of axiomatic logic.

Unfortunately, a survey of the calculator instruction manuals reveals once again the "textbook" approach. For instance, every book tells its reader how to calculate miles per hour, but none tells him how to determine the accuracy of his answer. Determining how much paint is needed to cover a room is another favorite. None of the books caution that different methods of application and different types of surfaces can make a significant difference in coverage.

Just about everyone has seen pictures or read descriptions of the family computer information center of the future. Most drawings have a walnut-and-chrome sleekness. And the descriptions of how people will use the computer systems are usually just as sleek. Without the proper mathematics training, people will probably use the system to play electronic ping-pong and balance their checkbooks. It will be just another fancy gadget.

But with an intuition and some information about ways computers can contribute to practical situations, we can make the computer as significant in our lives as the automobile.

David F. Salisbury is Science Editor for the Christian Science Monitor *and a regular contributor to* Technology Review.

Soviet Exports: How to Make Sales Without Telling Tales

Washington Report
by
Colin Norman

Regulations were developed during the cold war to control exports of potentially strategic goods to the Soviet Union and eastern Europe. They have been a source of vexation in corporate board rooms and a source of anxiety in the Pentagon ever since. Now they are coming under increasing scrutiny in Washington. A significant change in government policy, with relaxation of controls on some high technology goods and tighter restrictions on others, is likely to emerge later this summer.

The revaluation of export controls is taking place for several reasons, chief of which is the fact that East-West trade has increased sharply in recent years, following the advent of détente. Total exports from the United States to Communist countries last year, for example, are estimated to have reached $2.7 billion; between 1972 and 1974, exports of products incorporating advanced technology quadrupled, reaching nearly $500 million a year.

Those figures worry some Pentagon officials and conservative politicians who believe commercial transactions are eroding the United States' technological leadership and adding, directly and indirectly, to the Soviet Union's military capabilities. Senator Henry M. (Scoop) Jackson (D.-Wash.) has repeatedly expressed such views. During a Senate debate a couple of years ago, for example, he warned that the Soviet Union is exploiting its trade with the United States "to the hilt." Senator Jackson added, "We and our allies have gone down the road of unimpeded free trade for a quick buck with our totalitarian adversaries before."

But on the other hand, some industrialists complain that controls on exports to Communist countries are so cumbersome and outmoded that they are stifling trade in nonstrategic goods.

In a sense, both those views are correct. A considerable amount of embargoed technology has indeed leaked through our controls; a typical route is the export of goods from the United States to a firm in Europe, which then sells them to the Soviet Union. The Commerce Department attempts to plug such leaks by blacklisting firms that violate controls, but by then, the goods have already reached their destination. At the same time, it is also likely that the lists of embargoed goods include products of little military significance, and the procedure for obtaining export licenses for shipments behind the iron curtain is so tortuous that it does indeed place a damper on trade.

Keeping Secrets

Against this background, a top-level Pentagon advisory group of senior government officials and industrialists has proposed a number of revisions of our export policies. Its proposals range from the sensible suggestion that export restrictions be clarified, to such absurdities as the recommendations that countries who allow controlled goods to be passed on to the Soviet Union should be punished, and that the Department of Defense should explore ways to monitor and control the training of citizens from Communist countries at American universities.

The committee's proposals received scant public attention when they were published a few weeks ago. Now they are being analyzed by a Pentagon task force, which hopes to make recommendations for implementing them by early June. Some indication of the significance attached to the proposals can be gauged from the fact that the committee which drafted them — a special task force of the Defense Science Board — included the Director of the Defense Advanced Research Agency, the Assistant Secretary of Commerce for Research and Development, the President of McDonnell-Douglas, and representatives from the White House and the C.I.A. It was chaired by J. Fred Bucy, Executive Vice President of Texas Instruments. Clearly, the proposals deserve close attention.

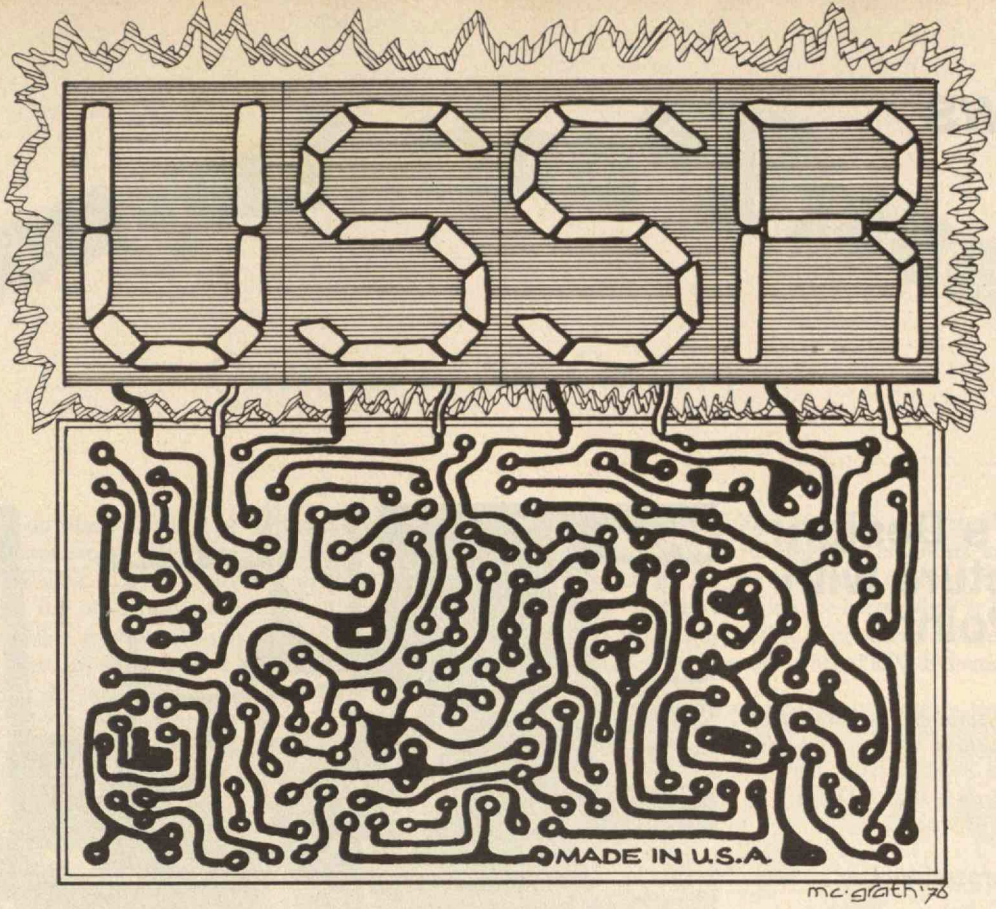
The committee argues that export control policies should concentrate on preventing the transfer of essential design and manufacturing knowledge for advanced technology goods. Export of the goods themselves often presents little problem, unless they can be used directly for military purposes. Therefore, the committee essentially argues that export restrictions should concentrate on controlling the flow of technology rather than the flow of technological products. It is an important distinction.

Current regulations are enforced through labyrinthine national and international arrangements which frequently irritate would-be exporters. The Office of Export Administration (O.E.A.) in the Department of Commerce maintains a list of embargoed technologies and products known as the Commodity Control List. Any firm wishing to export items on the list must apply for a license from O.E.A.; its application is considered at a weekly meeting of representatives from the Department of Defense, the Department of State, the Energy Research and Development Administration, the C.I.A., and elsewhere. Sales considered unlikely to add to the Soviet Union's military capabilities are usually approved. But since O.E.A. receives as many as 200 applications a day, the process takes considerable time.

In addition, western countries maintain an informal arrangement to provide some conformity in their export controls. A committee known as the Consultative Group Coordinating Committee (CoCom), consisting of N.A.T.O. members minus Iceland and plus Japan, maintains its own list of controlled technologies and products and seeks to ensure that member nations follow similar export control regulations for trade with Communist countries. CoCom also meets weekly, in Paris.

The Defense Science Board suggests that both the U.S. Commodity Control List and the CoCom lists should be drastically shortened by removing items of little military significance, and items which are unlikely to transfer design and manufacturing knowledge. (There have been some changes in the lists since the cold war; such obviously strategic items as brassieres and wigs are reported to have been deleted.)

The amount of time saved by eliminating applications to export innocuous goods should be spent on preserving the secrecy of more important technologies. In particular, the committee suggests that special attention should be paid to three



transactions: those involving the export of "an array of design and manufacturing information plus teaching assistance which provides technical capability to design, optimize, and produce a broad spectrum of products in a technical field"; exports of "manufacturing equipment required to produce, inspect, or test strategically related products"; and exports of products "with technical know-how supplied in the form of extensive operating information, application information or sophisticated maintenance procedures." These suggestions are sensible enough. If they could be implemented — given CoCom's requisite agreement to changes in its list — they would actually increase East-West trade while preserving the secrecy of essential technologies. But the committee unfortunately begins to go awry when it suggests ways of enforcing the controls.

Unfriendly Persuasion

Proceeding from the observation that "some CoCom members have perceived less need to maintain strict controls while the opportunity for individual gain through the sale of technology to Communist countries has increased," the committee argues that "strategic technology has been transferred to Communist nations through CoCom-sanctioned exceptions, ambiguous interpretations of lists, and, perhaps, conscious violation of CoCom agreements." To plug such leaks, the committee suggests that "in the future, the U.S. should impose a sanction upon any CoCom country that fails to control a specific technology, by restricting the flow of know-how in that technology to the offending country."

As for non-CoCom members, the committee expresses "particular concern" about the acquisition of high technology know-how by nations in the Middle East, and "the assimilation of know-how by nations of western Europe that are not members of CoCom — principally Switzerland, Sweden, and Austria." It suggests that the United States should release to non-allied, non-Communist countries "only the technology we would be willing to transfer to Communist countries directly," and that any CoCom nation which allows embargoed U.S. technology to be re-exported to the Soviet Union should be cut off from further exports of strategic technology.

Such heavy-handed application of sanctions against the United States' western allies would surely cause considerable bitterness that would be likely to diminish CoCom's effectiveness. Though there are certainly good reasons for a total embargo on transfer of some technologies to unstable areas of the world — such as nuclear reactors and reprocessing plants in the Middle East — trading sanctions between the United States and its western allies won't exactly cement cracks in the western alliance.

The Department of Defence would be better occupied in seeking ways to strengthen CoCom. The result could be international agreement on ways to ensure maximum trade while preserving essential technological information. Indeed, after recommending sanctions likely to weaken CoCom cooperation, the Defense Science Board argues in the same breath that CoCom should be strengthened.

But if the proposed sanctions are shortsighted, the committee's recommendations for policing the transfer of technology within the United States are downright insidious. The committee urges the Department of Defense to study "active mechanisms for transferring technology that are beyond the normal scrutiny of export control administration," and it suggests that recommendations should be developed for "monitoring and controlling them." Among such mechanisms, the committee lists "government-to-government scientific exchanges" and "the training of citizens from Communist countries at the more significant laboratories of U.S. technical institutes and universities."

Though it may well be, as one committee member told me, that the committee did not mean to propose that the Department of Defense should (illegally) keep tabs on foreign students in the United States, it is not readily apparent what else the committee might have had in mind. The Department of Defense would do well to dismiss such Cold War notions, and concentrate instead on the committee's sensible suggestions for improving East-West trade without sacrificing U.S. technological leadership.

Colin Norman is Washington Correspondent for Nature *and a regular contributor to* Technology Review.

Book Reviews

Women's Design: Architecture with a Fine Point

From Tipi to Skyscraper: A History of Women in Architecture
Doris Cole
Lincoln, Mass.: i press., inc., 1975, xix + 136 pp.; $8.95, $4.95 paper

Reviewed by Margaret Hickey

Photo: H. A. Frost

Doris Cole thoroughly documents the contributions of women to American architecture. As she points out, the "skyscraper" end of the architectural continuum barely exists within the compass of women's achievement. However, with skyscraper cities in growing financial and environmental trouble, women's virtual exclusion from this architecture may not be so tragic. In any case, it is becoming clear that skyscraper architecture is not the final answer to the depressing appearance and unhealthy physical and social condition of our cities.

It has never been simple to make habitable environments for large numbers of people. Often enough, we have misunderstood the social, economic, and legal implications of our buildings. And now, there are more and more factors to juggle: shortages of energy, materials, and skilled craftspeople; increasingly tough building codes; worsening pollution levels; tighter financing; and an ever more complicated built environment.

Nonetheless, during the last decade, we seem to have learned a few things: for instance, that massive urban removal does not work, and that a collection of detached towers does not make a neighborhood. Many people who live in "less is more" buildings find that "less" is, in fact, "less."

More . . .

An appreciation of false economy in buildings now hovers in government and business consciousness. The people who mind budgets are sometimes seeing what an extra bay window, balcony, alcove, or tree can do towards keeping a building rented and in good condition. The truth is that as we have built bigger and more uniform environments, people's tastes have stayed pretty much the same. They still like to be able to open and close their windows, to watch their children play, to have a place to put the sewing machine or the bicycle, to identify and associate with their space, to feel it is special.

Any architectural or landscape feature of a design, besides costing a certain amount and taking a certain amount of time to deliver, install, and maintain, has various possibilities of human association which may be extremely important. A tree, for example, may lead quite a social life. That tree may be the one under which Mary proposed to Fred, under which Harry was conceived, beside which Hazel eats her lunch, around which shoppers shelter in the rain, at which Willy looks thankfully every morning, beside which Susan waits for her father, up which Lesley hides, on which Rover relieves himself, and in which squirrels and birds live. Hospitable window seats and doorways can live a similar catalogue of events.

With so many people heading to homesteads in the country, we should get the message clear: much in our cities is barren, boring, and devoid of possibilities for humane use. But knowing this is one thing; trying to do something about it within the current economy is another.

It is all very well to educate architects to construct liveable places from scratch. But especially as population levels off, adaptive re-use of existing buildings and neighborhoods will become much more important. There is still plenty of work to be done, but it must be humble, considerate of its surroundings. Let us pray the days when city planners and architects wiped out blocks of old housing with a single well-intentioned swipe of a magic marker are gone forever.

In the last two years, special courses by preservation groups have proliferated. But the issue is not limited to preserving places with historic significance. We cannot in good conscience destroy sound, unhistoric buildings when materials are growing scarce. In many cases, buildings once considered ordinary show extraordinary, beautiful detailing and a craft and mate-

Continued on p. 70

Conversation Pieces

Question of the Century

Is there life on Mars? If there is, we hope this masterpiece of miniaturization will prove it. Built by TRW, it packs into one cubic foot the equivalent of three organic chemistry labs full of equipment that's been designed to determine whether micro-organisms exist in the Martian soil. It also contains the complex electronics needed to gather the data for transmission to Earth. Several weeks after July 4th, 1976, when NASA's Viking (built by Martin Marietta) is scheduled to land on Mars, scientists hope to answer the question that has tantalized men for so long.

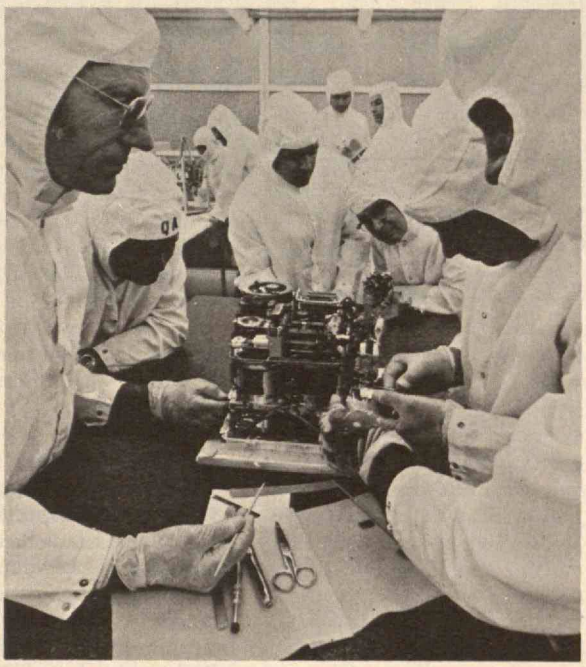
Another TRW-built experiment on Viking will measure the violent winds and cold temperatures of the red planet's tenuous atmosphere. Meanwhile, TRW engineers are working on further experiments designed to probe the hot, dense atmosphere of Venus, later this decade. With Earth's atmosphere "bracketed" by the opposite extremes of these two natural laboratories meteorologists may get new insights into our long-range climatic trends and weather processes.

These experiments are only the latest of many TRW projects designed to help NASA explore the solar system. In 1958, Pioneer 1 was the first spacecraft ever built by a private firm. It showed the shape of the Van Allen belts and measured interplanetary particles and fields. Later Pioneers observed solar disturbances and the solar wind from as far away as the other side of the sun. The most recent Pioneers have crossed the asteroid belt, made close-ups of Jupiter, and sent back more data on the interplanetary medium from record-breaking distances. One is now headed for Saturn and the other will become the first man-made object to leave the solar system.

During the nineteen sixties, TRW built NASA's series of Orbiting Geophysical Observatories, which mapped the Earth's magnetosphere and provided detailed data on phenomena that affect long-distance communications.

We've now started building three High Energy Astronomy Observatories for NASA. Designed to look far beyond our solar system, they'll map sources of X, gamma, and cosmic rays across the entire celestial sphere and then concentrate on the most interesting ones. The results should help answer key questions about quasars, pulsars, black holes, and galactic explosions. They may even throw new light on man's basic theories of energy and matter and on how the universe began.

In skimming the highlights of such projects, it's hard to avoid sounding boastful. But the engineers and scientists who actually do the work have no time for bragging. They're too busy applying the lessons they've learned to new and even more difficult problems. These hard-working people, in fact, are what TRW Systems is all about. If you're interested, we'd like to send you a couple of booklets that give you an overview of our diverse capabilities and more information about the Mars instruments. Just write on your Company Letterhead to:



Building the Viking Lander Biology Instrument involved the use of more than thirty different types of advanced technology.

TRW
SYSTEMS GROUP

Attention: Marketing Communications, E2/9043
One Space Park Redondo Beach, California 90278

Trend of Affairs

Trends This Month

SPACE

Martians: Stand Up and Be Counted

Project scientists deny that the primary justification for the Viking mission to Mars is the search for life. They emphasize the importance of the data that can be gathered on planetary formation, seismometry, geology, and meteorology. But N.A.S.A. sold the idea to Congress on the basis of the life-search experiments, and the public enthusiasm for the July 4 landing on Mars has since validated the wisdom of that strategy. The search has so far put five years, 1,000 scientists and engineers, and over $63 million into the development of an active biology package for the Viking mission.

The Viking investigators began by asking those hairy questions that citizens may now just be encountering:
— What is life?
— Can it be the same on earth and Mars?
— How will we know when we find it?

It was not necessary to formulate a definition of life specifically for the project, explains Klaus Biemann, Professor of Chemistry at M.I.T. and team leader for the molecular analysis experiments. Life is defined by that which differentiates it from non-living matter. "Life is a system which reproduces itself, can change through mutations, and can pass on those changes through succeeding generations. Most people think of life as something that can crawl," says Dr. Bieman. This conception is much too narrow — life is defined by a large number of chemical reactions that take place and by an inbred set of instructions that guide and regulate these reactions. Life does more than passively endure; it survives. A characteristic, such as crawling, is merely an adaptation to ensure survival, certainly not a universal characteristic.

But naming these "universal characteristics" of life is a difficult matter. Our experience is so far limited strictly to earth. Formulating a universal definition of life means that we have developed a "planetary" rather than an earth science.

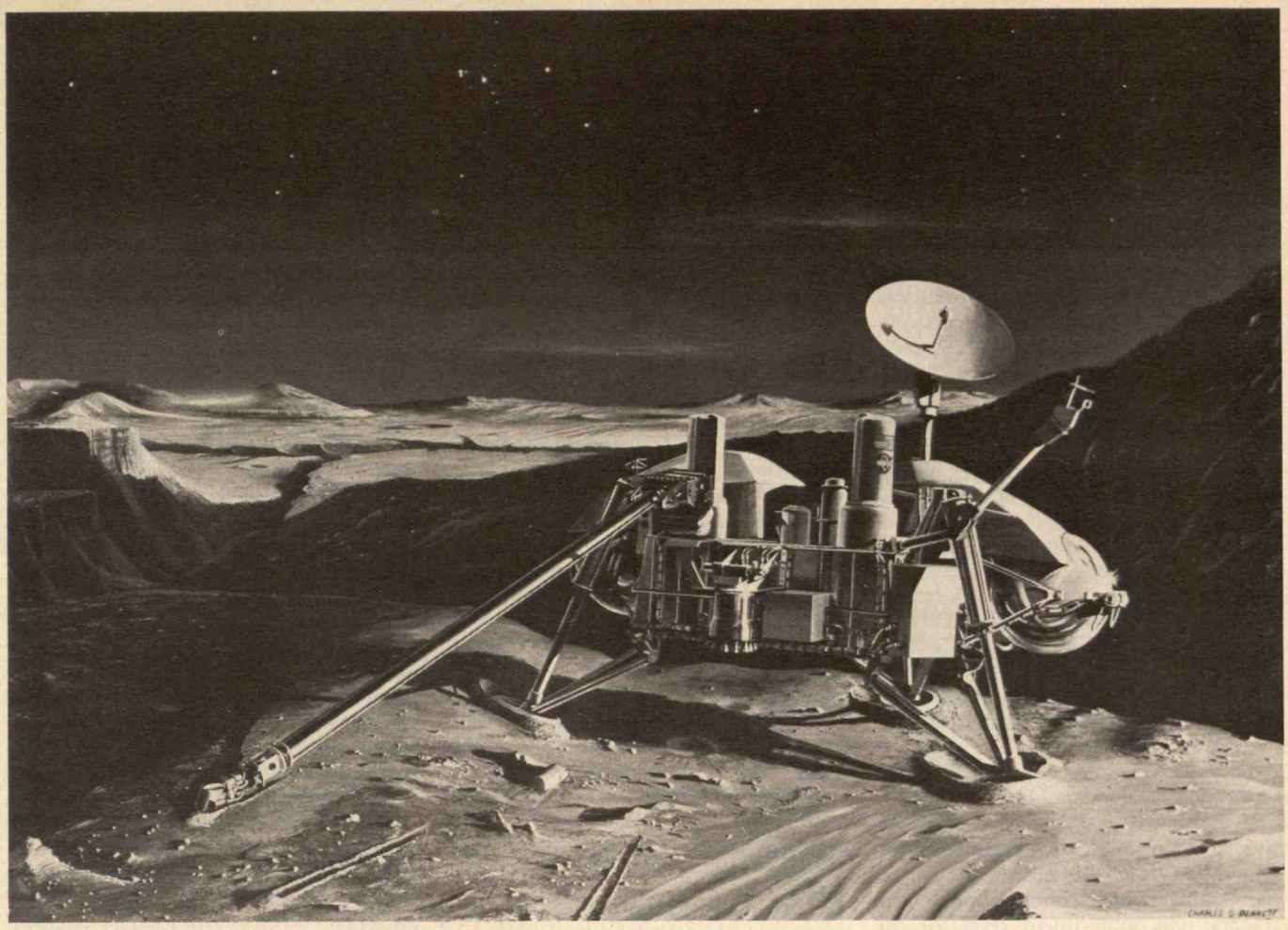
To an extent, we do have the basis for a planetary science, Dr. Biemann says. We are certain that the laws of physics and chemistry are the same on Mars and earth. We can be certain that simple molecules of ammonia, methane, and water, under the influence of heat or electricity, will coalesce into amino acids, the building block of proteins, the basis of life. This is called the theory of chemical evolution, and one aspect of the Viking project is to determine the extent of Mars' chemical evolution. The atmosphere of the young, primitive earth is supposed to contain these elements; our very existence is tribute to the basic physical and chemical laws we now use to probe Mars.

One component of the Viking project indirectly related to the search for life is the search for organic chemical compounds on Mars. On earth, organic compounds — carbon atoms linked to one another or to atoms of hydrogen, oxygen, nitrogen, or sulfur — are almost exclusively by-products of life's activity. But on Mars there may be other sources for organic molecules. They may originate under the Martian surface, formed by thermal processes and outgassed through Martian volcanoes. They may be products of photochemical reactions in the ultraviolet-filled Martian atmosphere. They may have come to Mars as unwitting hitchhikers on meteorites. Or they may be evidence of living creatures.

Dr. Biemann points out that the presence of organic compounds on Mars is not as equivocal a life-indicator as it may seem. An organic chemist has one certain method of differentiating a life-produced organic molecule from a geologically produced one. "If we could find a set of organic compounds, the *coexistence* of which could not be explained by chemical reactions, then we would be driven to conclude that life does exist on Mars," says Dr. Biemann.

Earth Chauvinists All

The old joke about the Martian asking the fire hydrant to "take me to your leader" contains a lesson in exobiology: all our



A 10-foot extendable boom is built onto the front of the Viking lander. At its end is the small scoop that picks up Martian soil. The arm pivots to dump the dirt into a funnel-like receptacle atop the lander. (Drawing: TRW Inc.)

assumptions about life in general must be based on our own limited experience on earth. For example:

— We assume that life on Mars must have a microbial "community" which supports larger organisms, as does earth.

— Since earth creatures are at least 50 per cent water, we assume that water is essential to life. Water vapor is found on Mars in only minute quantities, but earth microorganisms have been known to survive in conditions just as austere. Scientists do not rule out the possibility that the Martian environment at one time contained sufficient water for life to emerge and then, for some unknown reason, became dry. Dormant life might be revived if water were to be reintroduced, they theorize.

— We assume that Martian biochemistry must be carbon-based. The possibility that Martian life might be based on silicon or ammonia has been studied, but discarded because of Mars' similarity to earth.

One basic geocentric assumption underlying the entire project is that we believe there is something on Mars worth looking for.

"Two or three decades ago everyone believed there was life on Mars. The orange color, the changing polar caps, Percival Lowell's canals all seemed to indicate some sort of life-based activity," says Alexander Rich, Sedgwick Professor of Biophysics at M.I.T. Professor Rich is a member of the Viking biology team. He voices the assumption implicit in the search for life: "Why should we be unique?"

Faith that life exists on Mars was not shaken until photographs from the 1968 Mariner-4 flyby showed only barren, moon-like landscape, he said. But Mariner-9, which sent back photographs of a geologically active planet, raised life scientists' hopes again. Mariner-4's photos had shown an atypical example. Now Dr. Rich thinks the likelihood of life on Mars is perhaps one-in-a-thousand; nonetheless "the significance of a positive discovery would be very great. It would be difficult, even if Vikings' initial experiments prove negative, to totally rule out life on Mars."

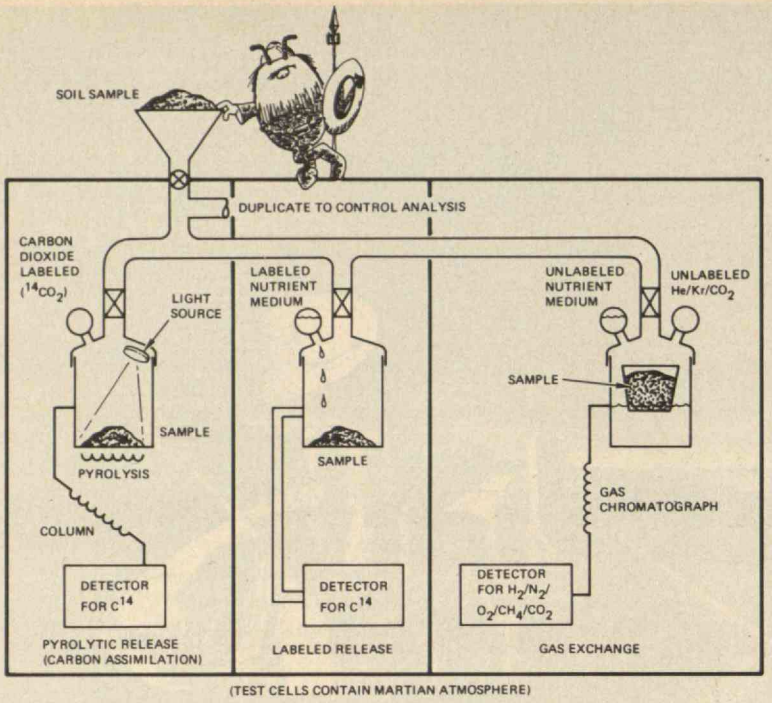
Chicken Soup for Martians

The first Viking lander is due to set down on Mars on July 4. Nine days later, experiments will begin. The life detecting component of the lander contains a cubic foot of intricate instrumentation, weighing only 35 pounds and capable of performing experiments which should give some indication of whether life is a unique earthly phenomenon.

The experiments are based on the theory of chemical evolution — that, under given conditions, life will inevitably occur. They will try to determine at what evolutionary stage Martian life exists, or at what stage it was arrested. The experiments will test for metabolic activity — chemical reactions which indicate the break-down or build-up of molecules containing carbon. These metabolic processes are basic to life, and can be detected by remote instrumentation.

In the carbon assimilation experiment, the least earth-chauvinistic of the three experiments, radioactively labeled carbon monoxide and carbon dioxide are pumped into a soil sample and incubated under a "Martian" sunlamp. This experiment will test for the synthesis of large carbon compounds from small carbon compounds. It closely duplicates the Martian environment, and will detect what we on earth would call photosynthesis.

Under the assumption that water is the necessary ingredient for life to become ac-



Viking shows off his biology instrument. The soil filters through a sieve into a metering instrument that doles out precise amounts to each tiny biology lab. (Drawing: TRW)

tive, the labeled release experiment moistens the Martian soil and then incubates the sample, which contains radioactive tracers. The experiment tests for the break-down of carbon-containing compounds into smaller molecules. It assumes that a microorganism which metabolizes or "eats" the soup will give off labeled carbon wastes that can be measured.

The gas chromatograph experiment moistens a sample of Martian soil with a vitamin-laden "chicken-soup" of organic molecules and incubates the sample in the dark for up to three weeks. A gas chromatograph measures the atmosphere above the soupy mixture: any unexplained changes may indicate that some life process is taking place, possibly a "respiration" by Martian organisms.

The pitfalls are numerous: the water or the organic nutrients supplied by the "soup" may inhibit or poison, rather than encourage Martian life activity; the time scales projected for the experiments may be unrealistic; the temperatures at which the experiments are conducted may be wrong.

Project scientists wear their pessimistic faces when speaking of possible results of the experiments. A positive result will have to be tested and retested. A negative result may mean nothing more than that life is not measurable by the scientists' criteria. Nothing less than absolute surety will suffice for them to believe that life, as they have defined it, has been found on Mars. — *S.J.N.*

Neutron Star or Black Hole?

When a star exhausts its nuclear fuel, it collapses, though no astronomer has ever seen this, and no computer has so much as simulated it. Still, there is the evidence of the supernovae — stellar explosions more cataclysmic than any other explosion known in the universe — and of neutron stars — the collapsed remnants, evidently, or supernova explosions.

The ultimate collapsed object would be a black hole — an object so gravitationally puissant that no light can escape it. For the theoreticians, black holes come in all sizes, from pinpoint-small to universe-huge. Some theories of gravity, general relativity included, permit their existence; others do not. Whether black holes truly exist, however, is a question for astronomers, not theoretical physicists — a matter of searching for them in the sky.

The technique for finding a stellar-mass black hole is to search for a dark collapsed object whose mass is greater than can be explained by the only known alternatives: white dwarfs and neutron stars. A white dwarf is kept stable by pressure among its electrons — pressure due to quantum mechanics, not classical physics. Should the white dwarf be sufficiently massive — 1.4 times the sun's mass — its gravity overcomes this pressure and there is further collapse. Now the electrons are forced into the nuclei; they combine with protons to form a collection of neutrons — a neutron star.

The pressure that sustains the neutron star is a pressure among neutrons. The problem is that electromagnetism (the force of electrons) has an accepted theory, but the strong interaction (the force among particles in an atomic nucleus) does not. Extrapolating known nuclear physics to arbitrarily high densities, theoreticians have asserted that gravity will overwhelm a neutron star greater than two to three times as massive as the sun, and, thus, a dark object over this weight limit must be a black hole.

The theoreticians' work has gained observational importance in recent years with the discovery and weighing of several dark objects in our galaxy. Cygnus X-1, at four to eight solar masses, is perhaps the most popular contender for the heavyweight title of black hole. But two M.I.T. physicists have now managed to fatten up neutron stars enough so that Cygnus X-1 qualifies as a neutron star.

The physicists, Professor Kenneth Brecher and graduate student George J. Caporaso, assumed only that Einstein's special and general relativity held at nuclear densities and above. The nature of the strong interaction at ordinary nuclear densities was not allowed to constrain their theorizing. The result was a higher upper mass limit for neutron stars — they might be five solar masses before their gravity makes black holes of them.

The moral, says Professor Brecher: "Don't assume what you don't know." — *M.F.*

Chandler's Wobble

In 1891 a Cambridge merchant named Seth Carlos Chandler discovered that the earth does not always spin smoothly on its axis. It's the "Chandler Wobble," but neither Mr. Chandler — he was an avid amateur astronomer — nor anyone else since has been able to explain its cause or to link it to other apparently random geophysical fluctuations in the length of the day and the behavior of the earth's magnetic field.

An explanation arises (like most of modern geophysics) from plate tectonics, and from Frank Press, Head of the M.I.T. Department of Earth and Planetary Sciences, and Peter L. Briggs, his graduate student:

Large earthquakes — eight or more on the Richter scale — actually represent displacements of the earth's continental plates, a tiny change in the earth's shape. This leads to a tiny change in the earth's rotation — a change (so small that only atomic clocks can detect it) in the length of the day. This wobbling in rotation is slowly damped as momentum is transferred to the earth's fluid core, where it reappears as disturbances in the earth's magnetic field.

The series of changes may take five years, and another five years may be required before all these variants are damped back to normal. — *J.M.*

Electronic Dollar Short-Circuited

They sat there in the exhibit hall dutifully sucking in plastic cards and spewing out money; bright and efficient computerized, automatic bank tellers, ready to revolutionize banking, eliminate the teller, and serve the depositor.

And they just sat there. The Docutel, IBM, Mosler, Diebold, and Burroughs machines were not being purchased eagerly by the bankers attending the 28th Annual Conference of the National Association of Mutual Savings Banks in Boston last winter. They are, perhaps temporarily, the victims of economics, law, and just plain human orneriness.

A few years ago many bankers predicted that by 1980 from 60,000 to 100,000 of the machines would inhabit banks around the country. But, according to Linda Fenner Zimmer, an authority on banking automation, there are now about 4,000 such devices in service and orders for about 3,800 more, so the 1980 forecasts will almost certainly not come true.

The machines had appeared very promising. For about $40,000 or so, a bank could obtain a reliable device that could be operated by the customer to do everything except tie his shoelace — deposits, withdrawals, transfers, balance-telling, etc. The devices gave 7-day, 24-hour service and eliminated waiting in line.

According to Ms. Zimmer, three major factors hindered the automated tellers' acceptance:

— An uncertain regulatory environment in which federal and state agencies created a blizzard of rules on automated tellers located off bank premises. So today almost all the machines must be installed at the bank, rather than at local supermarkets;

— The confusing relationships between automated tellers and so-called point-of-sale terminals, which allow purchases to be paid for at a store's check-out counter with credit cards or checks electronically OKed by the customers' bank; and

— The dismal economic situation that slowed banks' commitments to all kinds of electronic banking innovations.

And unlike many other computer installations, the terminals themselves offer no hard dollars-and-cents economic justification for themselves. Even with all the arguments about convenience and good public relations, according to a representative of one automated teller company, bankers must accept on faith that the machines are good for business. And peddling faith to a banker would seem as effective as peddling a BankAmericard to a Trappist monk.

The banks themselves have made frequent mistakes in promoting the new machines, according to Ms. Zimmer. In some cases they have failed to educate customers in the machines' use, restricted the distribution of cards for the devices, and haven't supported the systems' management.

Her studies of the automated tellers revealed useful tips for bankers, and interesting human factors. For one thing the machines seem to bolster one another. When a second bank installs machines in a city, the first bank finds that its machines come into heavier use.

A personal demonstration appears the most effective means of customer education in the machine's use, but it is difficult to get the customer to the machine. Some banks have resorted to demonstration vans, having customers pick up their electronic cards in person, or installing demonstration hostesses in the lobby to snare business.

One of the most important ways to get new customers to use the machine may be the little button on it that allows them to find out their bank balances. According to Ms. Zimmer, it appears that many customers gain confidence in the machines by getting their balances a few times, before getting into the heavy part — putting in and taking out money.

Everybody uses the things. Although the first customers were typically middle-class male breadwinners, this was primarily because the first permit cards used were standard credit cards. But now students, shoppers, old, and young use the machines. Ms. Zimmer reported that minority group members in New York especially like the devices "because machines don't hassle them like tellers."

For the customer, the bottom line seems to be that he will get whatever he demands. One new study of the savings bank industry reported that "the competition for consumer deposits would increase dramatically and that the traditional savings bank depositor — the individual — would be the most important source of deposit liabilities for the banking industry," according to Verne S. Atwater, president of M.I.N.T.S., a service organization to the industry.

So, the depositor is king, and since the costs of such electronic services are falling rapidly, he should be extra hard-nosed in the future about demanding those services — *free* — from the bank. — *D.M.*

Reading Machine for the Blind

As important and successful as braille has been in allowing the blind to read, it has never allowed the blind person to encounter the world of print on its own terms: all readings must be translated to braille; the sense of touch is a poor way to translate print into concepts. The several devices developed to translate print directly into vibrating patterns of pins, musical tones, etc. for the blind to "read," are just as slow and tortuous as braille to learn and use.

Now, it appears that mini-computers, character recognition, and linguistics have finally combined to provide the blind with a device to read aloud to them. In January, Raymond Kurzweil, the 27-year-old president of Kurzweil Computer Products, Cambridge, Mass., announced development of a machine which can read a wide variety of printed matter, deduce the correct pronunciation, and recite it in an understandable voice.

Building on five years of work at M.I.T. and elsewhere Mr. Kurzweil and his colleagues now expect another year or so of testing by blind persons before the device is marketed. Its initial price, $10,000 to $25,000, will make it attractive only to large institutions, but the expected drop to $5,000 to $10,000 in ten years will place it within an individual's price range.

A blind person using the machine places the text on the reading console's flat glass plate where it is scanned by a lens system attached to a charge-coupled device scanner. The scanner finds the first line of print, and an attached mini-computer begins interpreting the letters, combining them into words, determining the pronunciation, and reading the words aloud — at a rate of 200 words per minute. The machine voice also pauses for commas, periods, etc.

To allow better understanding, the user can direct the machine to pronounce one word at a time, or to spell out any word or sequences. In past tests, blind persons have learned to use the machine's controls in a few hours.

The keys to the machine's success are the pattern recognition system which applies general rules to the recognition of a letter, and the pronunciation system, which uses a few simple rules to compute pronunciation, even of unusual words.

But the real breakthrough, says James Gashel, chief of the Washington office of the National Federation of the Blind, is the machine's impact on people. Blind persons are frequently caught in a vicious circle, in which their handicap shuts them off from the world, causing them to withdraw from the world, which further isolates them. The Kurzweil system could help break the circle, allowing the blind almost full access to the world of print, on the easiest of terms. — *D.M.*

A "Frog Crisis" in U.S. Water

The balance of nature in a fresh-water pond can teeter on a tadpole. And if there is a "frog crisis" in the U.S., a whole range of U.S. water-quality problems may be at stake.

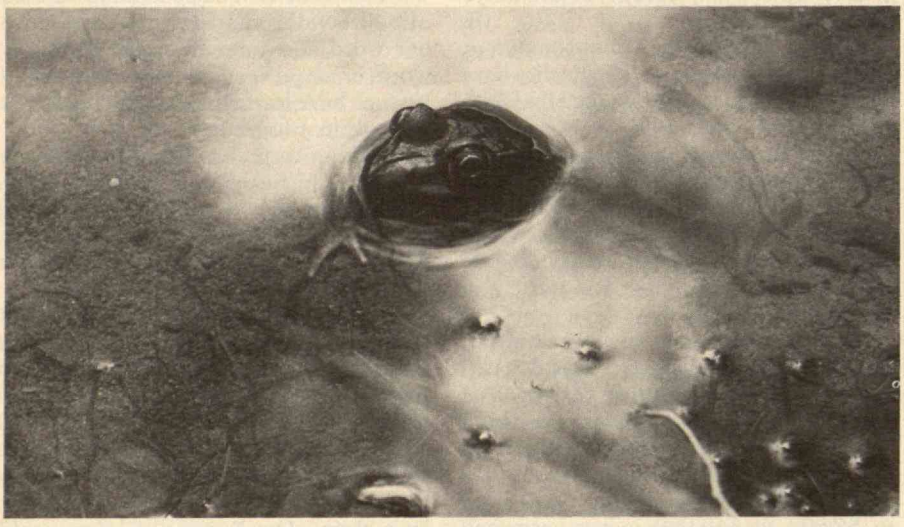
As a graduate student at Washington University, Dianne B. Seale (now research associate in biology at Pennsylvania State University) studied the balance of algae and tadpoles in a muddy-bottomed pond near Eureka, Mo., for 18 months. Tadpoles are what Dr. Seale calls "nonselective filter feeders." In their search for algae for food, they suck up all kinds of pond debris; some of what they collect provides nourishment and much of the rest is trapped in their body wastes and discharged in fecal units which settle to the bottom of whatever pond they're in.

Dr. Seale hypothesized that filter feeding of tadpoles might substantially affect water quality in ponds in which they live. Indeed so, at least in Eureka, Mo. Dr. Seale attributes three effects to tadpoles:
— They remove particulate organic matter, including algae and bacteria.
— They release organic and inorganic wastes which are potential nutrients for planktonic organisms.
— They deposit particulate matter in fecal pellets which have the role of sediment.

The correlation of water quality with tadpole population was clear — the more tadpoles, the better the water. More than that, the correlation is so good that Dr. Seale thinks tadpoles are "significant tools for investigating the properties of aquatic ecosystems."

A practical contribution to environmental knowledge? Yes, insists Dr. Seale, and she is determined to learn more about tadpoles and frogs as soon as she can. "Before it's too late," she says, because there is growing concern among biologists about declining U.S. frog populations. Three midwestern biologists have proposed that the number of frogs in the U.S. declined by 50 per cent in the decade of the 1960s. "Man has introduced 'unnatural' factors (chemical and biological wastes, insecticides, fertilizers, and water management programs) which are destroying frog species on a grand scale," wrote Erich L. Gibbs in *Bioscience* in 1971. (He was then Director of Ultrascience, Inc., Skokie, Ill.)

Even the lowly tadpole . . . — *J.M.*



The more tadpoles in a pond, the better the water, concludes Dianne B. Seale. The polliwogs act as the pond's garbage detail. They are "nonselective filter feeders" who process pond debris in their unceasing search for food. (Photo: Stock, Boston)

Climate Predictions Conflict

One robin does not make a spring, and one cold winter (or two) does not presage an ice age. Temperature and rainfall data over the last 100 years indicate no climatic change at all, according to University of Maryland climatologist Helmut E. Landsberg.

So much for the recent hulabaloo over the climatic effects of man's industrial enterprises, he told the American Association for the Advancement of Science this winter. We will neither swelter in a carbon dioxide-induced greenhouse nor freeze in a world blanketed by particles. Some of those who think we will, he said, have not considered all the evidence.

Dr. Landsberg referred to an area whose weather once "proved" climate change. The Sahel region of Africa, which suffered an extreme drought in the early 1970s, has returned to normal. Rainfall data kept in Dakar, Senegal, since 1882 indicates that such a drought and subsequent return to normal weather "can be expected once in a century."

"Normal" weather contains more extremes than most of us imagine, he said. The earth's natural axial wobble has much to do with climatic fluctuations, as do 12-, 24-, and 80-year cycles of sunspots. In fact, when weather fluctuations are treated as quasi-random variables, all are completely within the expected range — "a typical statistical noise pattern."

This random pattern is ubiquitous: the African and Indian monsoons now arrive on schedule, but the midwestern rains wax capricious. Dr. Landsberg does not discount the serious effects of local weather extremes, particularly in marginal agricultural areas such as the sub-desert or the arctic tundra.

Data presented to the A.A.A.S. by Gunnar I. Roden of the University of Washington support Dr. Landsberg's thesis. According to long-term records — some of them dating back to the 1805 Lewis and Clark expedition — there has been no persistent change in the air temperature of the Pacific coast for the last 100 years. Temperatures have risen and rainfall patterns have shifted in heavily developed urban areas due to the heat from homes and industries and the altered reflectivity of paved or developed areas. These areas seem to be islands of climatic change, but do not affect the weather of the coast as a whole. Ocean temperature governs the latter.

Carbon Dioxide Dangers

But mini-climates around cities are climates nonetheless, and human activities have definitely warmed and wetted those areas. So W. S. Broecker, Professor at Lamont-Doherty Geological Institute, took exception to Dr. Landsberg's proposition. Dr. Broecker thinks the question is not whether man influences climate, but whether he will continue to do so. His fatalistic conclusion: "Since we're determined to burn fossil fuels, the best we can do is foresee and prepare for the results."

The carbon dioxide that worries him all comes directly from the burning of fossil fuels. Carbon dioxide is now being added to the atmosphere at the rate of about 0.9 parts per million per year, and will be added at a faster rate as fuel use grows (Dr. Broecker figures two per cent per year until 2100). But the real effect of the added carbon dioxide won't emerge from the statistical "noise" cited by Dr. Landsberg for 20 or 30 years, he cautioned. By then some valuable natural "sinks" — nature's commode of excess molecules — will be loaded with carbon dioxide. The

gas, impossible to remove once it is liberated from its fossil fuel prison, will remain in the atmosphere in excessive amounts.

Our carbon dioxide saviours have been, until now, the biosphere (mainly the photosynthesis of plants) and the ocean. Only about half the carbon dioxide from burning fuel has landed in the atmosphere, Dr. Broecker told the A.A.A.S. The other 45 per cent mixes into the upper few hundred meters of the ocean, combines with phosphorus, or is converted by plants. But the ocean mixes slowly, and will become saturated with carbon dioxide within 20 years, he said. Then we will see a world-wide temperature rise of about 2.5°C. by 2100.

Uncertainty surrounds the effects of dust and clouds on the atmospheric temperature balance, Dr. Broecker admitted. This uncertainty disturbs him. Paleoclimatic reconstructions of the ice age estimate the temperature 10,000 years ago to be about 5°C. lower than present. "When doubling the carbon dioxide in the atmosphere only achieves half the effect of a glacial era, there's obviously something else at work."

"Nothing we've thought of could give a big enough nudge to climate except the sun," he added. "Maybe the sun blinked." Or maybe the unknown properties of the atmosphere intensified the effect of an event similar to the addition of large amounts of carbon dioxide.

Save the Forests

If the oceans do become saturated with carbon dioxide, we will be forced to rely completely on the biosphere to absorb the excess.

By then, the photosynthesizing biosphere may have been burnt, eaten, or turned into parking lots. This, too, will affect climate. Forests, the world's most efficient photosynthesizers, are most necessary to survival and climatic stability. They are in immediate danger, according to George M. Woodwell, Director of the Ecosystems Center of the Woods Hole Marine Biology Laboratory.

Measurements of the carbon dioxide content of the atmosphere oscillate from season to season, rising in the winter and falling in the summer. The summer lows can be attributed to the metabolism of carbon dioxide by plants in foliage. Thus we are dependent on plants for a stable climate as well as for food and fuel.

The entire biosphere produces 172 billion tons of dry organic matter per year. To follow Dr. Woodwell's logic: half of that is now used to support human activity. Forests produce up to three times more biomass per unit of area than do cultivated or grass lands. Human needs will grow with population; thus more forests will be harvested for fuel, or cleared for cultivation and habitation. We have only a small and diminishing cushion of biological resources.

Dr. Woodwell calls the reduction of the earth's forests "partial cause for the increase of carbon dioxide in the atmosphere ... and a net reduction in the earth's capacity for life."

"Together, the increase of carbon dioxide and the decline in the earth's biota constitute the most important threat to the biosphere short of nuclear war," said Dr. Woodwell. "Biotic impoverishment and human impoverishment are inexorably united." — *S.J.N.*

Pushing Back the Continents' Birthday

Plate tectonics, the mechanism by which "plates" of crust drift across the earth's liquid core, has dominated the evolution of the earth's surface. For 3.5 billion years, the earth has looked much as it does now — continents, some flat, some mountainous, washed by the sea of water that distinguishes the earth from other planets. If the planetary system is no more than 4.5 billion years old, its condensation from a solar nebula must have taken place in less than 1 billion years — a rapid transformation indeed.

Details of a billion-year-long era in earth's history now called the "middle planetary," beginning perhaps 3.5 billion years ago, have been made clear by geological analyses completed within the past five years. According to these analyses, the processes of accretion and differentiation occurred within a momentous era of less than 1 billion years. To understand how so much could have happened so quickly is "one of the greatest challenges" to earth scientists, says George W. Wetherill of the Carnegie Institution of Washington.

Here is how hypotheses in several fields of geological study have combined to yield today's "relatively clear" picture of the "middle planetary," according to a review paper for the American Association for the Advancement of Science last winter by Professor Kevin Burke of the State University of New York at Albany.

Lunar studies show that the great meteorite bombardment, whose craters remain the most visible features of the moon's surface, ended about 3.9 billion years ago. By then the moon was a chemically differentiated object, presumably in terrestrial orbit. The earth must have been similarly differentiated and even more heavily bombarded. The formation of organized continents and oceans is unthinkable until the end of this onslaught of planetary material.

The age of the oldest rocks on earth — 3.8 billion years — correlates with the end of the presumed period of intense meteoritic bombardment. Rocks so old as this are now known in many parts of the earth, says Professor Burke, giving general currency to the idea that "a large proportion, perhaps nearly all, of the present material of the continents had been formed by 3 billion years ago." If the continents were formed so quickly, so must have been the oceans, for no geologist can imagine how one could have happened in the absence of the other.

If the outer layer of the lithosphere is now cold and rigid, forming today's plates, so must it have been 3 billion years ago. But there was vastly more radioactivity in the earth then, and the earth's interior was warmer. So the continental plates must have been thinner and smaller and almost surely were in more rapid motion than today's. Geochemical surveys of today's rocks confirm this hypothesis.

Professor Burke's picture of "a considerable number of microcontinents, ridges and island arcs all in rapid motion with respect to each other" excites biologists. It implies extensive shallow marine shore lines, the most favorable environment biologists can imagine for the development of early life. And if the plates were moving faster there would have been frequent collisions — plenty of chance for prehistoric organisms to move between the continents and pervade the earth, as they clearly did. — *J.M.*

Billion years ago	
4.55-4.45	Accretion of earth
4.45-3.85	Heavy meteor bombardment
3.85-2.85	Oldest known earth rocks, extensive terrestrial volcanism
2.80-2.60	Oldest abundant earth rocks
0.60	Oldest well-identified animal fossils
0.20	Separation of North America and Europe
0.002	Evolution of man

Evidence from lunar, meteoritic, and terrestrial materials analyzed in the last quarter century has given earth scientists confidence to push a well-defined geological time scale back to include the earliest history of the earth; this table summarizes highlights of a history described by George W. Wetherill of the Carnegie Institution of Washington this winter. Another line was later added to the table by Professor Kevin Burke of the State University of New York (Albany): the continental crust had differentiated, the processes of plate tectonics were operating, and most of the world's water was in the ocean basins by 3 billion years ago.

Engineers Hinder Archeologists

While his crew was working on a section of highway 83 in South Dakota in 1953, a construction company president happened to spot three fossil teeth in the rubble of a cut; he sent them to the South Dakota School of Mines and Technology. Two days later Professor J. R. McDonald came down to take a look. The highway was passing along a Pliocene stream bed "loaded with fossils" of 10-million-year-old mammals — "a fabulous collection of animal remains," says Professor Mario G. Salvadori of Columbia University.

Most such stories lack such happy endings.

"In sections of California where there were 10,000 Indian sites 30 years ago," Professor Salvadori told the American Society of Civil Engineers last fall, "there were less than 1,000 left two years ago" — and all will be gone by 1980 if development continues apace. Over half the archeological sites in the eastern U.S., and 95 per cent of those in the Los Angeles area, have been destroyed.

High among the culprits are amateur archeologists, Sunday-diggers who collect illegally and carelessly. But professional archeologists' frustrations focus mostly on the construction engineer, said Professor Salvadori: he finds most of the sites, and most of the time he is also "responsible for the wholesale destruction of their contents."

The law is on the side of the archeologist, but that's academic; if the law is enforced at all, it's levied against individual pothunters, not on bulldozers and draglines. Professor Salvadori's plea to civil engineers is to learn what an archeological site looks like and notify the nearest university or museum when one is found. And a special word to their bosses: if the site turns out to have great value, take sides with our national heritage and let the archeologists have their turn — even at the cost of weeks, perhaps months, in the schedule. — *J.M.*

Colleges' Roles and Engineers' Mobility

The cresting wave of demand and popularity on which American universities and the people they educated were riding in the 1960s is a thing of the past.

At least for another decade, says Richard Freeman, Associate Professor of Economics at Harvard University, the fraction of college graduates in employment will be lower than the fraction of young people who elect to go to college. . .

. . . which is another way of saying, he told an M.I.T. manpower seminar, that the supply of college graduates will be greater than the demand for their talents until sometime in the 1980s. And by then the demand for college education and even the esteem of the institutions providing it will have been considerably eroded.

Professor Freeman's manpower analyses contemplate not only the conventional supply-and-demand variables which are built into most economic predictions. He adds a "feedback" factor: the decisions which young people make about their careers are heavily influenced by the conditions they perceive around them.

So it is, says Professor Freeman, that the "unprecedented decline in the labor market for college graduates in the 1970s" is breeding sharply reduced college enrollments for the rest of this decade. Indeed, he says, the "relative advantage of a college graduate in the U.S. labor market" may never again return to the historic highs of the 1950s and 1960s; and Professor Freeman predicts "a significant change in the role of colleges and universities" in American life as a result.

Are scientists and engineers — and the schools which educate them — exempted from this gloomy forecast? Perhaps, and for two reasons:

— The demand for scientists and engineers, in relation to the supply, is higher than for most other college-trained groups, said Charles E. Falk, Director of the National Science Foundations's Division of Science Resource Studies.

— Scientists and engineers are — always have been — mobile, changing their professional orientations in response to changes in industrial priorities and national needs. Said Lee Grodzins, Professor of Physics at M.I.T. who, with Porter Cogishall of the National Research Council, is just completing a massive study of scientists' mobility and adaptability: consider the totally new field of environmental science. It did not exist as an academic speciality a decade ago, yet now it is a popular curriculum on scores of American campuses. Of today's environmental scientists, 26 per cent hold doctorates in chemistry, 23 per cent in the biosciences, 16 per cent in earth science, 13 per cent in engineering, 5 per cent in physics.

Of 2,500 professionals now working in the new field of computer science, only 500 have doctorates in it; the other 2,000 are migrants. Indeed, 20 per cent of all scientists and engineers have left the broad field of their Ph.D.s, and nearly 50 per cent have left the specialized field in which they wrote their theses. "The scientist stuck in the rut of his profession is a myth." — *J.M.*

The Hazard of a Prophecy Fulfilled

Are women different from men in engineering classrooms and laboratories — and when they take jobs in engineering offices? They are indeed, says Mildred S. Dresselhaus, Abby Rockefeller Mauze Professor of Electrical Engineering at M.I.T. But the difference may not be what you thought it was.

The problem, says Dr. Dresselhaus, in a recent issue of I.E.E.E.'s *Transactions on Education,* is neither that women are less physically strong than men, nor that they are suited by temperament to some and not other activities. But enough people make those assumptions to cause many women engineering students and engineers to have "a very much lower self-confidence level" than men.

At many points in her career, a woman engineer will find herself "a minority member of a group activity." As such, a woman has more visibility than her male colleagues, and her natural reaction is to try to avoid calling attention to herself. If she's the only woman in a class, she tends to be quiet, thinks Dr. Dresselhaus, and she often avoids counsel even if she needs it. In somewhat the same way, some women are uneasy with high grades in engineering classes, because these grades are seen to result from feminine charm, not intellectual power.

In professional offices, men tend to have lunch together and leave the women out of what Dr. Dresselhaus calls an "informal 'buddy' system." "The typical woman engineer in an industrial setting will have to 'prove' herself more frequently and under less favorable circumstances than her male counterpart," writes Dr. Dresselhaus.

Lower self-confidence is the result of a series of social mores. Parents, teachers, and counselors simply don't expect women to be interested or skillful in engineering, and "it is only natural that the lower societal expectations for women result in a lower female aspiration level . . . and more self-doubt about their careers at every level of their professional development." — *J.M.*

The "Bin of Parts" Problem and the Ice-Box Box Puzzle

Cutting, shaping, and assembling materials into products people want is a primary function of engineering. Surprising, then, to find that members of the Society of

Manufacturing Engineers can list frustrating gaps in knowledge and scores of gadgets needed to design, make, and distribute things.

The S.M.E. members' want list came about when the Society decided to help college students find thesis projects whose results would be truly useful — in contrast to those yielding answers nobody needs. Here are some of the S.M.E. members' questions looking for answers:

— The "bin of parts" problems. After parts are made, and before they're needed for final assembly into larger equipment, they're stored in bulk in tubs and boxes. There is no machine today which can pick a part out of such a box, orient it properly, and feed it to an assembly machine. It's "the most difficult problem in automatic assembly," said Professor Geoffrey Boothroyd of the University of Massachusetts, and an answer would be worth "tens of millions of dollars" a year in the U.S.

— As materials grow tougher to meet ever-tougher operating requirements, tools to cut the materials must become tougher, too. Now workpiece materials are becoming "almost unmachinable," says Charles E. Glynn of General Electric Co., but there's been "no new class" of general-duty tool materials since carbide steels in the 1930s. "A real breakthrough" is what Mr. Glynn wants.

— A similar revolution is needed in cutting and grinding fluids. Irving J. Stewart of Cincinnati Milacron, Inc., complains that no one really knows in fundamental physical and chemical terms how cutting fluids — petroleum- or water-based — really operate to simultaneously lubricate, cool, and prevent corrosion of the workpiece. Basic knowledge would translate into improvements throughout the metal-cutting industry, says Mr. Stewart. And the need for new synthetic cutting fluids is "immediate," says J. Tomko of S. H. Mack and Co., Inc., Aurora, Ill.

— After the surface of a metal part is ground to final size and smoothness in the finishing process, surface stresses will remain; and it's now clear that these residual stresses affect the fatigue life of the part. H. G. Tueting of General Electric Co. wants a low-cost, nondestructive method for determining residual surface stresses which would replace the $300 (per specimen) method he now has to use.

— The corrugated-board carton for a home appliance costs about $8 — "one of the most expensive components" in many machines, says J. Edward Barton of Whirlpool Corp.'s Laundry Group. Mr. Barton wants a replacement which will be less costly and less a disposal problem for the buyer, and he thinks a $100 million annual saving could hinge on success.

— A subtler want from Professor Nathan H. Cook, Director of M.I.T.'s Materials Processing Laboratory. Manufacturers now lack a dependable means to measure — while they are in use — the wear on cutting tools. A tough problem, thinks Professor Cook: most tools deteriorate subtly, working just a little more slowly, or at a slightly higher temperature, or using more energy, each time they're used. "The basic problems of tool wear sensing have not yet been solved," Professor Cook and two colleagues reported to the National Science Foundation last fall. — *J.M.*

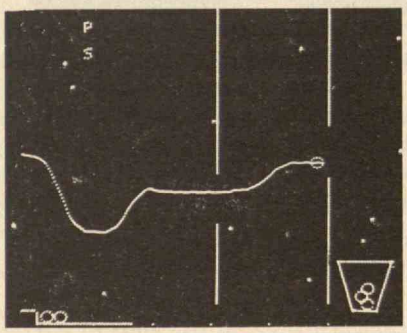
Computer Tutor for the Deaf

These pictures are of computerized displays designed by engineers at Bolt Beranek and Newman, Inc., of Cambridge, Mass., to help deaf children learn to speak intelligibly.

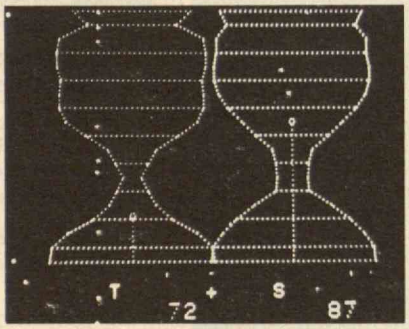
The problem is difficult. Children deaf since babyhood have no aural models to copy in learning to speak. Their speech is usually slower than that of hearing persons, at a higher average pitch, and often in a monotone. Rhythm and stress are often poor, nasalizing is often wrong, and some speech sounds are simply absent. Speech is often almost unintelligible except to intimates.

A visual index of their performance as speakers has now been provided for deaf children by R. S. Nickerson and Kenneth N. Stevens of Bolt Beranek and Newman (Dr. Stevens is Professor of Electrical and Bioengineering at M.I.T.).

After three years of work with 40 students — each having a 20-minute daily session for up to 14 weeks — Drs. Nickerson and Stevens report considerable improvement in deaf children's pronounciation of the material used in training — but little or no improvement in the intelligibility of their spontaneous speech. Partly, the engineers think, these disappointing results would be reversed if children spent more time with the teaching device. And they are basically encouraged, they told the American Association for the Advancement of Science last winter, because they are convinced that "the computer — because of its flexibility — represents a potentially powerful tool." — *J.M.*



To help a deaf child sense and control the pitch of his speech, R. S. Nickerson and K. S. Stevens of Bolt Beranek and Newman use this computerized display. The ball progresses across the display (leaving a line behind it), moving up and down in accordance with the pitch of speech. The goal is to control speech pitch so that the ball passes through the two slots at the right, whereupon it falls into the bucket.



The shape of this "goblet" figure is determined by the frequency spectrum of a sound, and the height of the ball in it represents the pitch of the sound. A teacher of deaf children creates the pattern at the left — a sound with which a deaf student is having trouble — while speaking; now the deaf student's task is to duplicate that sound, using the changing image of his own voice at the right.

The top trace represents the teacher's speaking of the phrase, "It's a pencil," with normal intonation; the words are animated by the variations in pitch, displayed vertically. The bottom trace is a deaf student's monotone speaking of the same phrase. The student's goal is to learn to match the teacher's pattern.

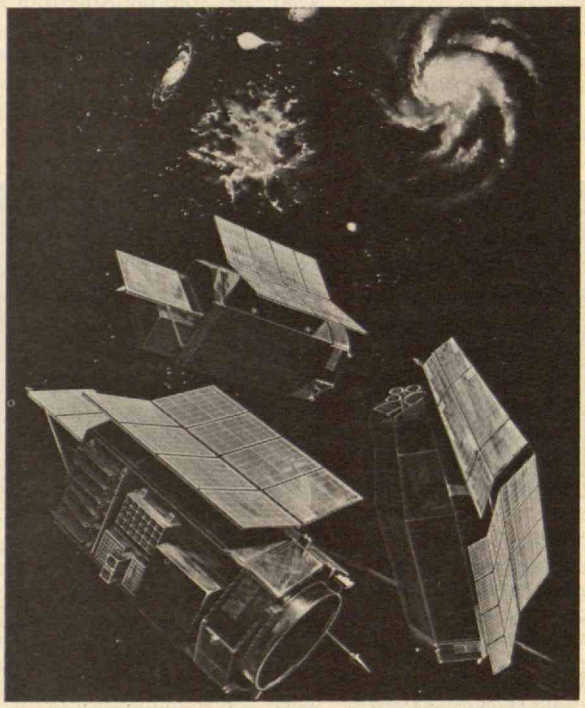
Conversation Pieces

Probing the High Energy Universe

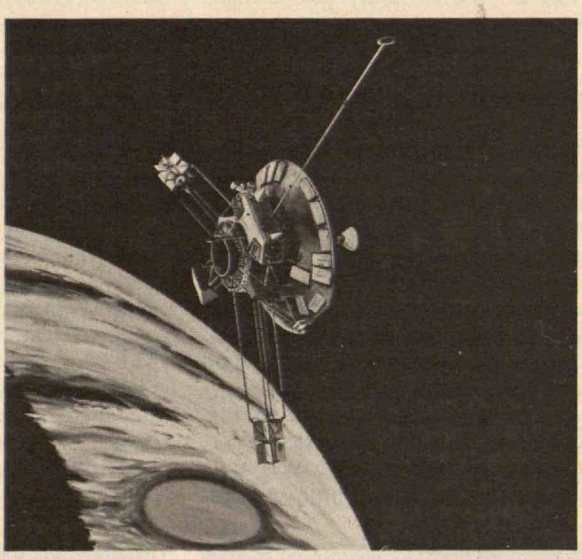
Since radio astronomy began, only a few decades ago, some brand new words have been added to the dictionary. Pulsar, quasar, black hole... these are only the most talked about objects and there are more questions about them than answers. How do these largely invisible but annihilatingly powerful generators of electromagnetic energy fit into man's basic theories of physics? Or do they fit? Are we on the verge of fundamental changes in scientific thought?

To find preliminary answers, instrumented balloons and rockets were sent above most of the Earth's atmosphere, starting soon after World War II. Then, small satellite observatories made better measurements. But the need for more prolonged observations and bigger instruments, with wider apertures, was obvious.

Now, NASA has given TRW the task of building a series of High Energy Astronomy Observatories and integrating their complex and massive experiments. HEAO-A will systematically map all significant high-energy sources over the entire celestial sphere. HEAO-B will point its wide-aperture X-ray telescope at objects of particular interest and measure their emissions with about 10,000 times the sensitivity of any previous instrument. HEAO-C will scan for cosmic and gamma-ray sources. The results may give us new insights into the physical processes which produce such interesting objects as pulsars, quasars, black holes, and other exotic astronomical phenomena.



The HEAO program is only the latest in nearly two decades of TRW projects designed to help NASA explore the solar system and the universe beyond. Back in 1958 our Pioneer 1 was the first spacecraft ever built by a private firm and the first of a whole series of low-cost, and highly reliable, interplanetary spacecraft. During the 1960s, TRW built the Orbiting Geophysical Observatories for NASA, to map the Earth's magnetosphere and provide data on phenomena that affect long-distance communications, In 1970-71, we built Pioneer 10, which made the first transit of the asteroid belt, the first close-ups of Jupiter, and, in 1987, will become the first man-made object to leave the solar system. Pioneer 11 has now swung round Jupiter and is heading for Saturn.

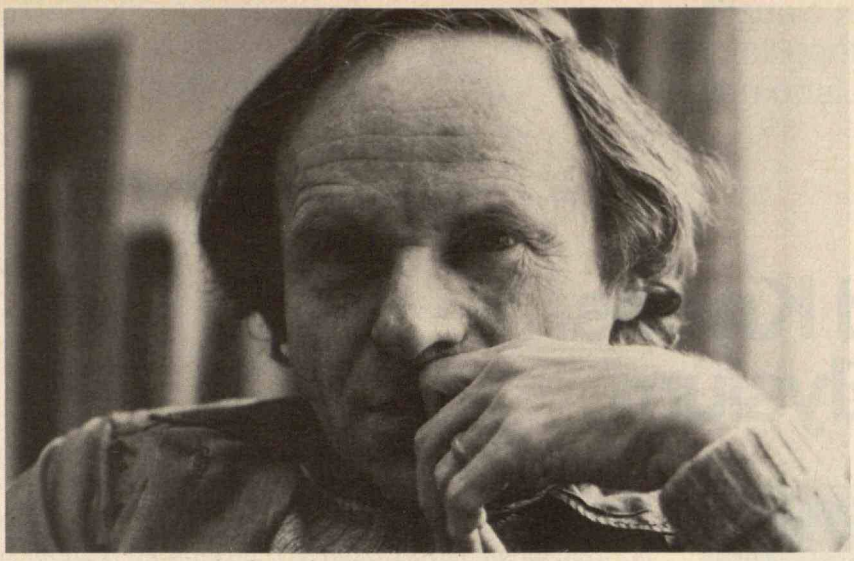


Space instrumentation is another long suit at TRW. Our Viking Lander Biology Instrument, a masterpiece of miniaturization and automation, is scheduled to reach Mars on July 4th, 1976, and start analyzing soil samples for signs of life. Another TRW instrument on Viking will make meteorological measurements.

If you'd like to know more about TRW in general and our HEAO work in particular, write:

TRW®
SYSTEMS GROUP

Attention: Marketing Communications, E2/9043
One Space Park Redondo Beach, California 90278



"A man gifted by nature with extraordinary curiosity and a keen mind"

—Galileo, "The Cicada"

Philip Morrison at 60: A Tribute by Victor F. Weisskopf

Philip Morrison is more than a person. He represents an attitude, a way of life, a symbol for what I would like to call "joy of insight" or "lust for knowledge." Nobody else has better demonstrated, or rather embodied, what it means to the human soul to perceive or recognize a new scientific discovery or a new theoretical insight. I use the word "soul" advisedly because Phil's character contains so much of it. Scientific knowledge and understanding is not a purely cerebral affair; it is soaked with emotion, excitement, and nervous tension, as everybody knows who has heard Philip Morrison talk.

The life of a scientist would not be worthwhile were it not for those few moments — maybe two or three per year — when he feels an exhilarating joy, deep in his guts, of having understood something, of having seen new connections that bring things together. "Now I know what it means!" These moments of joy occur from time to time, no matter whether it is one's own or someone else's discovery. In my life, more often than not, such a moment happened during a talk or a conversation with Phil. I remember an unforgettable talk at a Harvard evening seminar more than 20 years ago when he told us about Watson's and Crick's double helix just a few weeks after they discovered it. It was the physicist Morrison, who immediately recognized the immense significance of the discovery; and he gave us a broad picture in his inimitable way of how this development would revolutionize biology. We went away from it with pride to be alive at a time of such revelations.

Phil's strength is the broad-brush painting of the scientific landscape. You learn the great connections, the deep relations, and the far perspectives. Surely here and there some detail is lost and some conclusions are not quite tight. But these are a small price to pay for the great panorama and grand vista which we have in exchange.

Many people have asked how Phil can manage all this. When does he read all the books and journals, when does he acquire his phenomenal knowledge of what happens in all branches of natural science? On top of all this he has been the book editor of the *Scientific American* for the last 15 years, where he reviews four to six books every month and must read ten times as many. He possesses a phenomenal gift of the quick and thorough grasp. Have you ever seen him "read" a book by turning a page every one or two seconds? He knows the content and, what's more, he knows the significance and relevance of it (this fact has been experimentally tested). I envy this in him more than anything else.

Now and then Phil becomes rather impatient with us ordinary thinkers when we take too much time trying to follow his intellectual long-distance runs. But we suffer his impatience gladly, in return for so much enlightenment.

Every student at M.I.T. knows Phil's classic (or I should say romantic!) art of lecturing. You can count on a new and unconventional view of the subject. Surely we must listen carefully because the ideas come fast. There are moments when his throat muscles have a hard time to follow the speed of his thoughts. But these are the moments when the lecture hall is filled to the brim with the intensity and tension of his enthusiasm. If you need a proof that true science is not a dry and impersonal subject, go and listen to Phil.

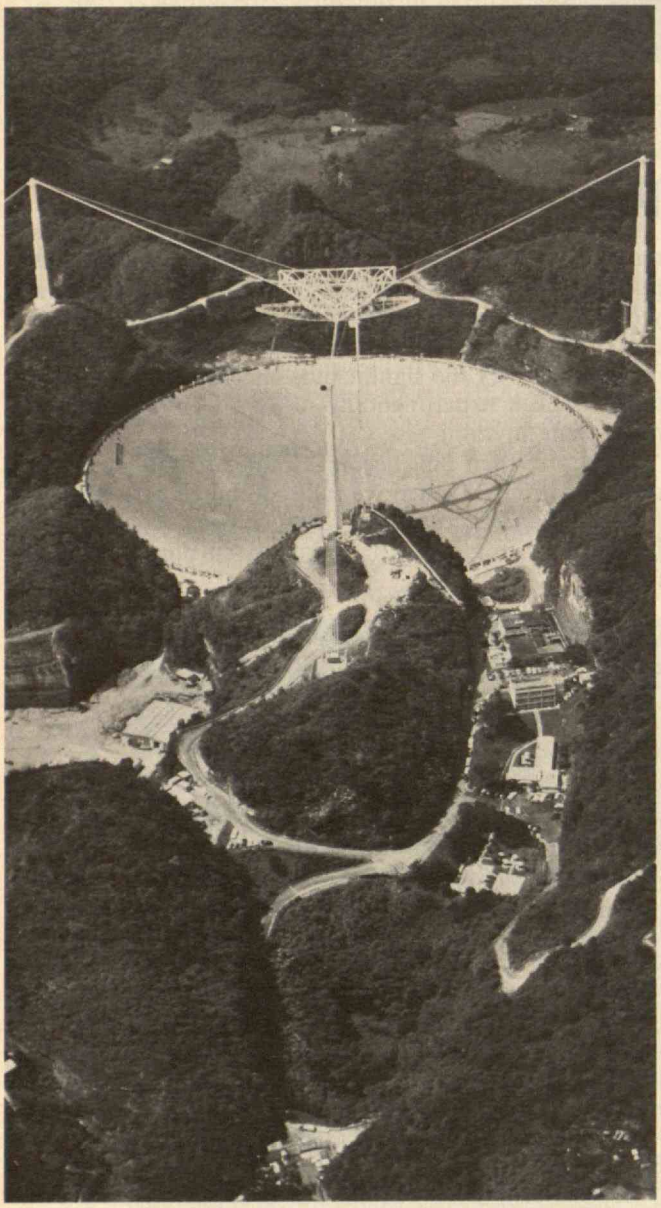
He has worked in many fields of physics and he is the best counter example to the narrow specialists of today. No wonder that his latest field of endeavor is that part of science with the widest and grandest scope: astronomy.

But there is more to his human approach to life than his broad understanding of science, the relation of man to nature. The predicament of man, social and political problems, education and health care have always been among his most important concerns. Everything human fascinates him — be it great, ordinary, or ominous. Whenever help is needed, whenever there is a cause to do some good, go to Phil; he will be ready and full of youthful enthusiasm. Is he really 60 now?

Victor F. Weisskopf
Institute Professor, Emeritus, M.I.T.
May, 1976

Frank Drake
National Astronomy and
Ionosphere Center
Cornell University

On Hands and Knees in Search of Elysium



In 1974, the giant, 1,000-foot radio telescope (above) at Arecibo, Puerto Rico, sent a message toward the Great Cluster in the constellation Hercules. Translated into pictographs (right), the message communicates the chemical formulas for the components of the DNA molecule (rows 3 to 6) and, more obviously, a human being and a pictograph of the Arecibo telescope, among others. The message will arrive at the Great Cluster in about 24,000 years. (Photo and chart: National Astronomy and Ionosphere Center)

Excerpts from the history of a science:

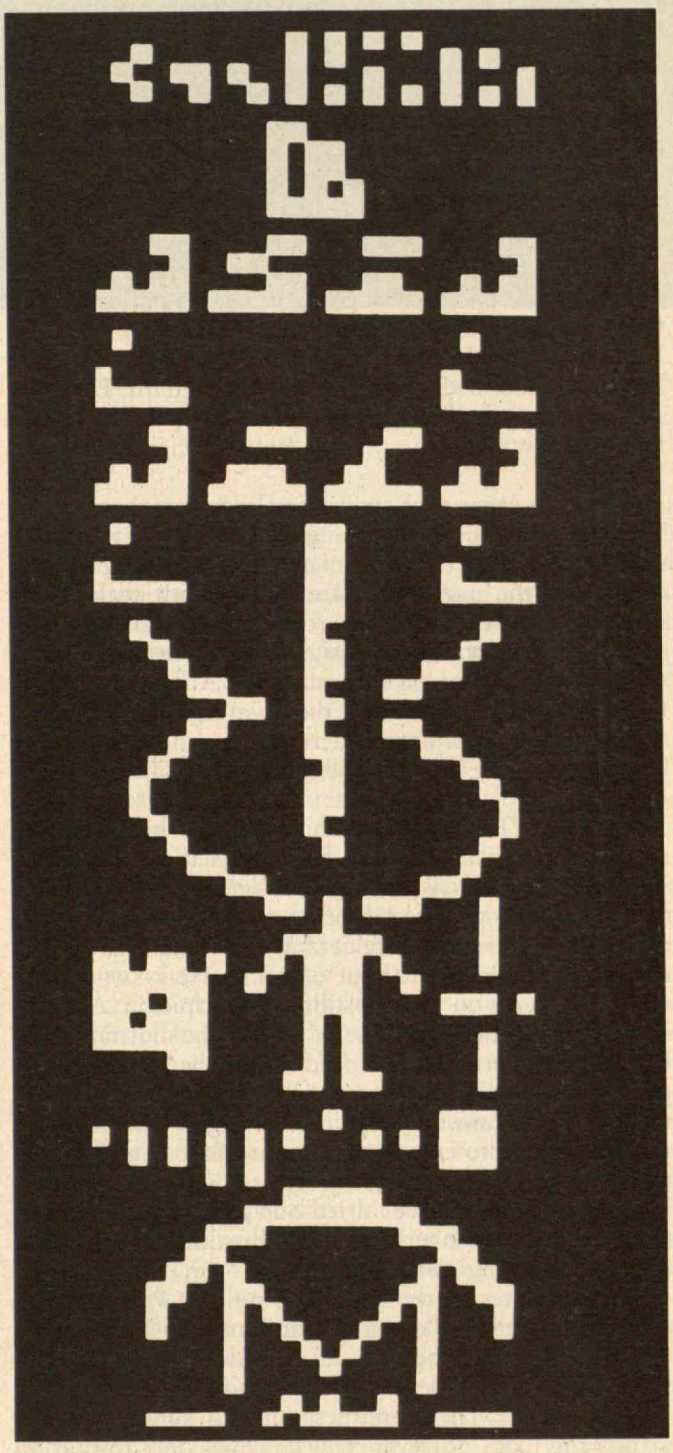
It is 1959. Readers across the world receive the latest issue of *Nature* magazine. It contains an article by Guiseppe Cocconi and Philip Morrison, "Searching for Interstellar Communications," which points out, for the first time in print, that our radio telescopes are sensitive enough to detect radio signals from distant stars, signals no stronger than radio signals being broadcast from earth. The Cornell University professors note that searching for the signals will be extremely difficult and time consuming, and conclude with the compelling statement: "The probability of success is difficult to estimate; but if we never search, the chance of success is zero."

Five hundred miles south of Ithaca, four astronomers, including the great astrophysicist Otto Struve, Director of the National Radio Astronomy Observatory, are driving into the West Virginia wilderness of Green Bank, where sculptured snowdrifts are fast yielding to the lush Appalachian spring. They are ignorant of the thoughts of Cocconi and Morrison. They stop to lunch in a tiny diner sarcastically known as "Pierre's," in the hamlet of Boyer. Over a hamburger and greasy french fries the lunchtime talk turns to a new idea. The new telescope at Green Bank could detect radio signals from telescopes no larger than itself at the distance of the nearest stars. With only small modifications and expenditures, the equipment at Green Bank could be altered to become an effective receiving system for intelligent signals. For all we know, the stars are more heavily populated and those populations more involved in technological activity than anyone imagines. Wouldn't it be worth making a search?

Thus, before the luncheon check is scribbled, the first powerful quest for extraterrestrial signals is authorized and organized. It is named Project Ozma, for a land far away, difficult to reach, and populated by strange and exotic beings.

Struve is pleased. His own work to map the spectra of stars, which had shifted the worldwide focus of astrophysics, has convinced him that planetary systems and life are abundant in the universe. Long ago, he had been an officer in the White Russian Army, fighting in the Russian revolution. Escaping to Turkey, he became a prisoner. The aftereffects of the hepatitis he contracted in that Turkish prison camp have afflicted him his entire life. He will spend his last few years in Berkeley, leaving Green Bank long before the searches for extraterrestrial life can be successful.

Signals are being broadcast by intelligent creatures — perhaps immortal. We may soon be tuning in



It is 1960. Stagnant pre-dawn cold and fog surround the 85-foot radio telescope which now stands stationary, pointing at the horizon. The radio astronomer at the focal point of the telescope carries out the endless twiddling of controls on one of the world's first parametric amplifiers. After 45 minutes the amplifier is adjusted to the delicate sensitivity required to detect extraterrestrial signals. In the chilly darkness below the telescope, two students, now wondering why they had left warm beds so early, giggle in the darkness as they call up to the focal point for progress reports on the amplifier tuning. Finally the job is done and the telescope hums as it commences its daily search for radio signals from two nearby stars, Tau Ceti and Epsilon Eridani. The scene will be re-enacted almost daily for two months. No signals will be found.

It is 1971. Twenty weary Americans have this day walked the dusty unpaved streets of the village of Byurakan in remote Armenia. They have gathered with as many Soviet counterparts there in a week-long, formal symposium to discuss all aspects of contact with extraterrestrial intelligent life. Historians, linguists, electrical engineers, cryptographers, and several Nobel Prize winners are in attendance. From this meeting will come the impetus for a host of new searches by both American and Soviet radio observatories. The meeting will lay the groundwork for a Soviet master plan for such searches, including utilization of a network of ground stations, the construction of giant antenna systems on the earth, and even the use of orbital radio telescopes for the pursuit of the elusive signals.

Later the Americans find themselves with an unfamiliar terrestrial problem. It is midnight and their Soviet jetliner, already four hours late in leaving Armenia (presumably to allow time for the Americans' luggage to be searched — the plane had been conspicuously standing ready the whole time) has been diverted by bad weather to a Moscow airport 60 miles from the one originally intended. The Americans' Russian colleagues have gathered to meet them in the wrong place. Worse, the astronomers are an inconsequential group in the huge mass of people stranded by the storm. Worst of all, this is the international airport and the Americans, with perhaps a thousand other travelers, are faced with an interminable wait to pass through understaffed customs; never mind that their flight was domestic. Fortunately, contrary to well-founded popular belief, Soviet officials can sometimes be influenced through the not-so-subtle application of bombast and anger. After 20 minutes of a Yankee

harangue in weary garbled Russian, the harried customs supervisor finally relents. The Americans may bypass customs. The stipulation: they must collect their bags and, following him, crawl backwards on their hands and knees across the luggage delivery racks dragging their bags behind. It must all be done within the next five minutes before anyone notices this remarkable departure from immutable procedures. No exceptions. Quiet pandemonium — the time limit must be met. Several Russians, who like all their brethren are always alert for loopholes in the system, see their golden opportunity. For a few minutes they act, as best they can, like Americans so that they may join the squirming conga line and escape this temporary gulag.

Outside the terminal there is a new crisis. In the driving rain and darkness several hundred people wait forlornly for the buses which may or may not come to take them to the city. Occasionally a taxi appears out of the misty rain; fights break out for possession of these getaway cars. The Americans are not qualified for this sport. They approach an Intourist official. This time harangues and insults get nowhere, but — contrary to all advice — a bribe does. Given five rubles, the Intourist official disappears into the darkness. A few minutes later he returns telling all to grab their luggage and follow him immediately, no questions asked. They run, then trudge, and finally stagger perhaps half a mile across what might have been a parking lot to find five dark commandeered taxis waiting. Phylis and Philip Morrison have more bags than anyone and end up being the most bedraggled, wettest rear guard. Dripping and cold, they huddle together as the taxis lurch off into the night toward the Soviet Academy of Sciences Hotel in Moscow.

When the Americans arrive they learn that there are no longer enough rooms for the group. They are to double up, and the wise hotel management has assigned the females in the party to share rooms with males with whom they have no marriage contract. A caucus succeeds in reorganizing the room assignments to resemble separate men's and women's dormitories. A few hours later the 20 Americans will be on their way again, to the land of twinkling computers and acres of aluminum waiting to be applied to the search for extraterrestrial life.

It is 1976. The night surf shimmers and breaks rhythmically on a dark Puerto Rican beach. In the neat, 30-room hotel above the beach, a sleepy night attendant (is he as old as Methuselah or does he only seem so?) for the third night in a row reluctantly awakens two Americans at the unthinkable hour of 4 a.m. He asks no questions, but looks on with hostility and suspicion. Any visitors at this resort who arise at four in the morning must be embarking on some evil deed. While the beautiful people sleep soundly, their expensive sunburns permitting, the two Americans drive off into the night. Chickens and toads scramble to escape the road in time. Carl Sagan is propped up in the front seat, eyes closed. He munches laboriously on scraps of dried-out garlic bread rescued from last night's dinner. It is all the breakfast there will be until the morning's observations are over.

An hour later as the sky turns pink, a Puerto Rican toad (the delightful "coqui") abandons its bell-like musical aria and crawls beneath an orchid plant for the day. Soon the wet, misty quiet is converted by the sun into a humid torpor. The brightness of the sunlight which warms the toad, however, will be equal only to that on Mars, for the toad is shielded by a canopy of 18 acres of perforated aluminum sheets — the reflector of earth's largest radio telescope. Five hundred feet over the canopy, murmuring machinery moves the 300-ton steel superstructure to direct the beam of the telescope to follow a distant galaxy, the Great Nebula in Triangulum, across the sky. A nearby building houses radio receivers, far more sensitive than those of 1960 and capable of covering 1,008 frequency channels at once rather than the single channel covered in 1960. These receivers capture and record the radio emissions coming from the galaxy. Every 30 seconds, 100,000 transistors invisibly transmit the recorded emission to the observatory's memory. The information captured in each of the 1,008 channels splashes a swath of twinkling green points across the face of an oscilloscope. It takes a hundredth of a second for the telescope to duplicate the two months of work done in 1960.

A split second of excitement. The astronomers, garlic bread and hunger now long forgotten, search the swath of points for a pattern which could not have been made by nature alone. When first their minds and later their hearts convince them that no such pattern is present, the command is given to move on, to look at another part of that distant galaxy — another billion stars — and to start the electronics searching and recording again. One hundred billion stars will be searched before the task is completed and the hotel night attendants will no longer have to awaken at 4 a.m. No signals will be found.

It is the present. At the Ames Research Center in California are two newcomers to radio telescopy, one a medical doctor, John Billingham, and the other, one of the geniuses of American industry, Barney Oliver. These men are leading the development of a magnificent and ingenious design for a giant radio telescope receiving system, called Project Cyclops, which would give us for the first time so great an ability to detect an extraterrestrial intelligent signal that it is probable we will succeed. Billingham and Oliver excel in leadership as well as in ingenuity and expertise. They have assembled and energized an outstanding group of scientists and engineers to optimize the design of the telescope and the planning for related intelligent-life-search activities, such as the assembly of catalogues of stars which are prime candidates for searches for signals. The chairperson of this outstanding group is Philip Morrison.

The high quality of the group's work has convinced N.A.S.A. of the worth of a full-fledged search for extraterrestrial intelligent life (S.E.T.I.). There is hope and even expectation that the work of those at Ames will lead to the investment of millions of dollars in the next few years for the development of receiving devices and computers that can adapt existing telescopes to S.E.T.I. Then may come the first steps in the construction of the multibillion-dollar Project Cyclops itself. These are grandiose and expensive concepts, to be sure. But the consequences of the detection of another civilization are themselves so grandiose that it is trivial to justify the investment of resources of such magnitude to achieve interstellar contact.

A Short-cut to Wisdom

Interstellar contact would undoubtedly enrich our civilization with scientific and technical information which we could obtain alone only at very much greater expense.

Ferns flourish in the shade beneath the 18 acres of perforated aluminum sheet which make up the bowl of the radio telescope at the Arecibo Observatory. (Photo: National Astronomy and Ionosphere Center)

More than that, it is extremely likely that any civilization we detect would be more advanced than ours. Thus it would provide us with a glimpse of what our own future could be. From this we might learn the best course of action in planning the development of our own civilization without wasting time and resources through the trial-and-error approach, which has been until now our only available avenue to progress. We would learn ways to improve the quality of life on earth at an unprecedented rate. We would learn what ultimate social systems are arrived at through evolution in other civilizations. Perhaps there are alternatives to choose from, some alternatives being better suited to certain biological forms and planetary chemistries and geologies. From this we could understand the way of life most likely to be best for us in the long run. We may discover that evolution inevitably leads to a single preferred mode of life. If this be so, let us know it now. We need not be afraid of interstellar contact, for unlike the primitive civilizations on earth which came in contact with more advanced technological societies, we would not be forced to obey — we would only receive information.

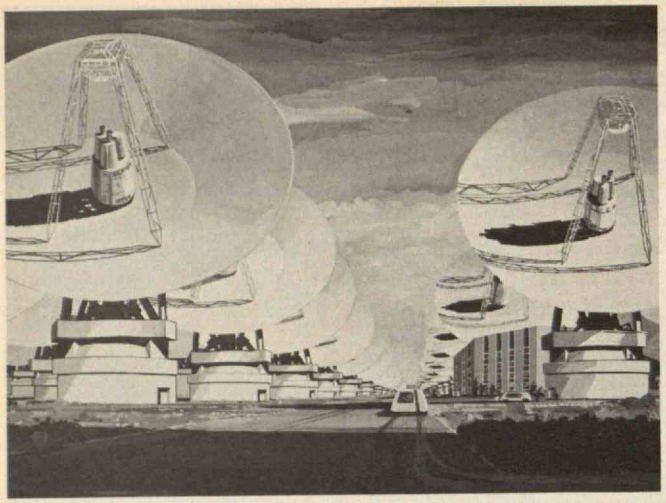
We would learn art forms and amusements in this universe, thus extending our own possibilities. And very likely we would learn profound aspects of intelligent life that we as yet have not begun to imagine. As with all explorations and scientific discoveries, these would be the most important of all.

Where do we stand after the long days of calculations, the long nights with telescopes, the interrupted sleep, bad food, and other adventures? I am tempted to say that we may soon detect an extraterrestrial radio signal; we may even detect one as you are reading this article. Our radio telescopes can easily detect signals no stronger than those we ourselves presently radiate, even from great distances in our Milky Way Galaxy. All the S.E.T.I. people have been tantalized by the belief that there are alien radio signals passing through our offices and homes which could be detected now with existing equipment if we but knew in which direction and on which frequency to listen.

Needles in a Cosmic Haystack

But the task is far greater than many of us have the strength to acknowledge, let alone tackle. We are searching for a few needles in a fantastic haystack of inconceivable size. We all know there are many places to search in the sky. The Arecibo telescope would have to point in 20 million different directions to examine the entire sky. And how many electromagnetic frequencies must be searched? There are good arguments that the optimum frequencies for interstellar contact and communication are those associated with radio wavelengths and not, say, optical or infrared wavelengths. This is primarily because galactic radio noise and quantum effects cause the energy required for information transmission to be markedly less at these wavelengths. Even with such guidance, to which the rest of the universe may not subscribe, the typical frequency channel width now used in interstellar searches, about 1,000 cycles per second, makes for some 10 million candidate channels. Already the number of bits of straw we must search through is more than 100 million million. A very big haystack.

Even so, if that's all there were to it, we could get on with the job using a quite reasonable radio telescope and computer installation. But what about the "what ifs"?



One proposal to search for signals broadcast by extraterrestrial beings is "Project Cyclops." For the project, an array of about 1,500 radio antennas (each 100 meters in diameter) would be connected to a large computer, creating a single collecting area which would dwarf our present collecting capabilities. The array might be located on the Mojave Desert. (Drawings: Ames Research Center)

What if a given civilization sends a signal our way only a small fraction of the time, say maybe a few hours a year? Then we must search every combination of direction and frequency many many times before hitting upon the brief interval when the signal is actually arriving here. The search could be lengthened thousands of times by this "what if?" alone.

And what if information is coded in radio transmissions in ways unexpected by us? We might well receive an information-bearing message and never realize it. We usually insert information into a signal by altering or modulating the signal strength or the radio frequency as time goes on. In television, for example, the picture information consists of changes in intensity of the radio signal, whereas the audio information is encoded by modulating the frequency of the transmission. Other possibilities are never used by us. For example, one could change the polarization of the radiation to impart information, say from right-handed circular to left-handed circular polarization. At this time no radio telescope looks for such modulation; yet it is entirely reasonable that such would be used, for polarization is an essential and profound property of all electromagnetic radiation.

And what if most civilizations are like ours, broadcasting a very few strong signals and a host of weak ones? In such a case the chance is small that any single one of few strong signals is beamed our way. If we can detect only these, then we must search at length until luck is with us, until we chance to be on the right frequency and at the right time when a powerful beam is pointed toward the earth. In such cases, it is possible that the totality of signals from the civilization is detectable even though the individual signal strengths are all well below the limits of detectability. In practice the detection of an ensemble of signals, each one by itself invisible, requires a mathematical treatment of the observational data which is very demanding on computer systems.

To be sure, it could be that the universe abounds in intelligent activity far beyond our most optimistic estimates. Or the signals of space could be far more powerful than ours of today — after all, measured on the cosmic time scale we are a technologically primitive civilization, having emerged into the electronic age only recently. If so, the "what ifs?" are but unreal nightmares, and we need only look at the nearest stars for brief intervals on a few frequencies to detect other civilizations. For this reason, scientists in many observatories in the United States, Canada, and the Soviet Union search the nearest stars and the nearest galaxies on a limited number of frequencies for limited times for evidence of extraterrestrial signals. Some 1,000 stars have been so examined in our own galaxy; most of these are among the nearest stars.

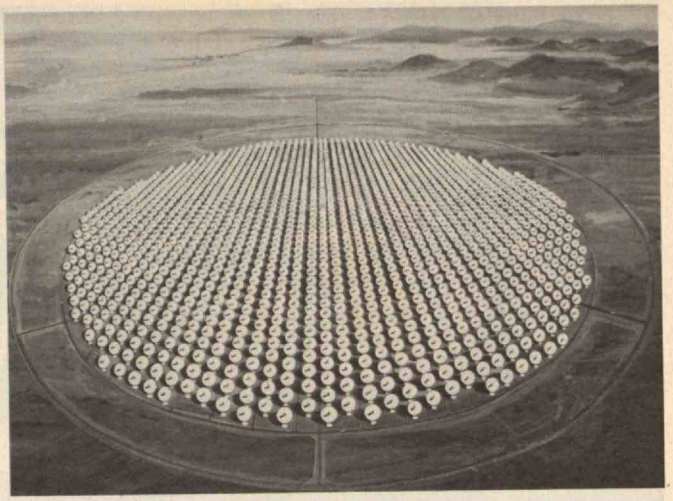
But a test of 1,000 stars on a few frequencies hardly begins the search of 10 million stars on many frequencies which we think is required. Four entire nearby galaxies have been searched, following an idea that rare civilizations may transmit far more powerful signals than the typical civilization, and these signals would be detectable even at the distances of millions of light years which separate the galaxies. In such a case, those civilizations would be easily found by looking at the nearby galaxies, and a complete search requires only a limited time with existing telescopes. The time required in this approach is much less than that required to test the 10 million stars in our own galaxy.

If there were once cockeyed optimists, there aren't any more, for none of these searches has brought forth evidence of a signal from other worlds.

In a way, I am glad. The priceless benefits of knowledge and experience that will come from interstellar contact should not come too easily. To appreciate them, we should be required to devote a substantial portion of our resources, our assets, our intellectual vigor, and our patience. Other civilizations may well generate signals intended to benefit others — signals that are strong enough only for the deserving to receive. I hope it is a cosmic rule: among civilizations there shall be no spoiled children. They must earn the right to their inheritence.

Wanted: Three Square Miles of Telescope

For our part, we have in fact laid down the design for Project Cyclops which could cope with the giant haystack and all the "what ifs?" The Interstellar Communication Study Group at the Ames Research Center is now attempting to identify the cheapest means to construct the formidable listening ability required. The design calls for a radio telescope receiving area 100 times larger than Arecibo, the largest collecting area on earth. The collecting area would be equivalent to that of a single telescope some two miles in diameter. As presently designed, it consists of some 1,500 individual antennas, each about 100 meters in diameter, all connected to perform as a single large antenna. The system would receive on perhaps a billion frequency channels simultaneously. The information from all the antennas and on all the frequencies would be fed to an enormous central computer system. There the signals from the individual antennas could be combined to produce information for all the frequencies for a



large number of different directions in space. The computers would search the signals received from all of these synthesized directions for the presence of strong signals and also for the presence of the ensemble of weaker signals which would mark an intelligent civilization.

Such a system would cost at least $10 billion, and operating costs would be many hundreds of millions of dollars per year. There may be cheaper and better ways. Right now the Cyclops Study Group is exploring such possibilities as a single large parabolic reflector in orbit about the earth, either close to earth or at very high altitudes, and also the possibility of building array telescopes, similar to the presently proposed Cyclops System, on the back side of the moon. This position has a particular advantage: it would be shielded from the constant radiation from the intelligent civilization of earth. Whenever we search, we find all kinds of intelligent signals coming into our system. So far, all have been powerful terrestrial signals scattered from aircraft, satellites, the moon, or even from the atmosphere itself. Elimination of such interfering signals from S.E.T.I. data creates an additional demand on the quality of the electronic and computer systems.

The commercial catalogues of earth's technology offer at a reasonable price every component needed to build a Cyclops system which could search the required number of stars successfully in a few decades. The obstacle to progress is not nature, certainly, nor even the level of our technology. It is our own motivation and wisdom. A large fraction of our population must be persuaded of the value if we are to invest the required resources (much less than is spent on cosmetics each year) at the level made necessary by the vast barrier of interstellar distances and all the hiding places in the haystack.

The Unresolved Life Span

One other "what if" has recently come to trouble me greatly.

To be sure, there will be many forms of intelligent life unimaginably different from ours. They will behave differently, and what is reasonable to them will be greatly different from our concepts of rationality. It could be that we cannot communicate with such creatures at all, even if we are able to detect them. There is no strategy we can now construct to cope with this plausible situation.

But what if they are immortal?

Immortality is a different matter. Rather than rare, it may well be very common. By immortality, I mean the indefinite preservation, in a living being, of a growing and continuous set of memories of the experiences of the individual in which the memories reside. This could come about by the development of methods to eliminate the aging process in humans, or it could come through the discovery of means to repair indefinitely the damage caused by the aging process. It could come about through the development of the means to transfer the inventory of memories of an old brain into a young brain, perhaps even the brain of a clone, an exact copy of a person whose individuality is to be preserved. Death could still occur through the physical destruction of the human being.

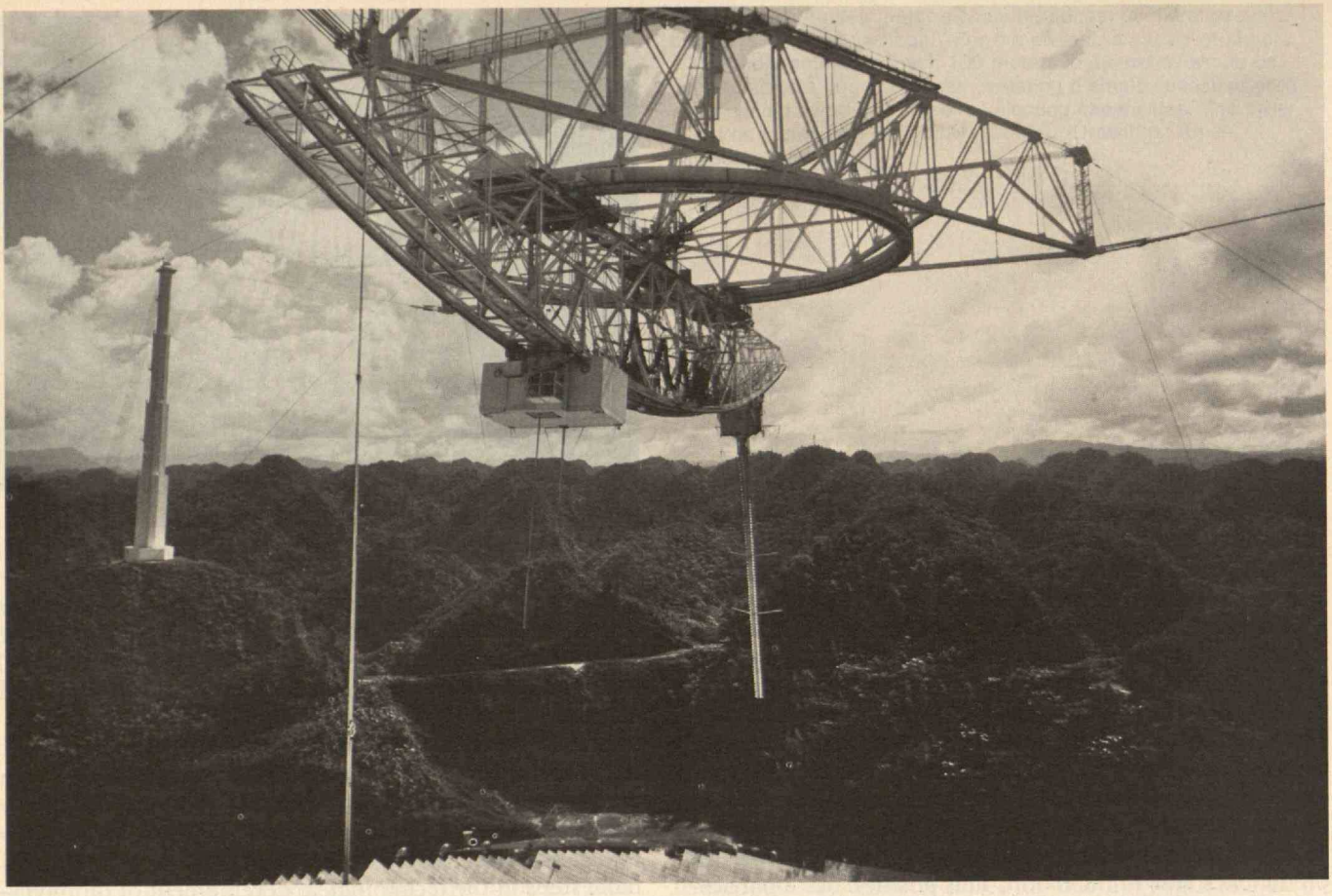
Some of these steps seem not far in our future.

Just as nuclear energy and radio telescopes were inevitable steps in the technological development of our civilization, so it seems entirely reasonable to expect that in the biological realm time will bring us immortality, just as surely as it brought us a cure for poliomyelitis.

Although we can grasp some of the vast differences between our lives and those of immortal individuals, the totality of differences between a society of immortals and our own is surely beyond our comprehension. Immortals must have a fantastic obsession with safety, and every device and vehicle must be so constructed as to present no lethal hazard under any circumstance. I suspect that the use of aircraft for transportation, or indeed for any purpose, might be impossible, since a falling aircraft is a hazard to those on the ground as well as those aboard. But then, after all, who would be in a hurry anyway? Wars would probably no longer occur because no one would take the risk of fighting. One wonders how new births would be administered. Obviously after a relatively brief interval, the number of persons living would reach some optimum number which could not be exceeded. At that point, new births could be permitted only when someone died — an event which would happen rarely. So, someone would have to decide who should be authorized to contribute to the replacement of a human being.

A civilization of immortals would probably be extremely active in detecting and communicating with other intelligent civilizations for several reasons. First, such a civilization would soon use up the resources for amusement and adventure in its own limited planetary system and would want to share vicariously in the adventures of other civilizations.

More importantly, the reverence they would attach to the preservation of individual lives would drive these immortals to avoid physical threat from another planet, even over the cosmic time scale. This may seem a remote



A 300-ton steel superstructure supports the antenna elements which transmit signals or receive signals from distant stars. The 96-foot line feed is necessary to transmit or collect signals, as the reflector is of a spherical geometry and not of the more conventional parabolic shape. All receiving elements must account for this departure from conventional shape. (Photo: National Astronomy and Ionosphere Center)

possibility, but they would have to be certain. They might in fact conceal themselves, and could prohibit transmission of radio signals detectable by other civilizations. This would not prohibit all signals, but only those so strong that they could be separated from the radio noise of the central star. But this would not stop a civilization with questionable intentions from seeking them out.

An immortal civilization's best assurance of safety would be to make other societies immortal like themselves, rather than risk hazardous military adventures. Thus, we could expect them to spread actively the secrets of their immortality among the young, technically developing civilizations. This hypothesis suggests that the numbers of their signals may well be much greater than we imagine.

A Search of Amazing Scope

One practical consequence results from this somewhat muddy situation: no matter what the immortals' philosophy, they have all the time in the world. Immortality destroys the need to do anything in a hurry. And, when it comes to radio signaling, this can be used to enormous practical advantage. For you can signal reliably to all parts of the galaxy with little power and expense by concentrating that power in a very limited frequency band.

Any signals we can now detect require such a power that it is reasonable to assume they are created by powerful radio transmitters whose output is concentrated into a narrow beam by a large radio telescope. This creates a high power level — but only in a small part of the sky. Such a transmission is an ineffective way to proceed if you don't know the location of the other civilizations. The best way to contact civilizations whose direction is unknown is to transmit through a small antenna or radio telescope which will spray the power over a much larger fraction of the sky. The resultant signal strength in any given direction is very much less. But you can compensate for this by confining the transmitted power to a much smaller band of frequencies so that the power level in each unit frequency interval is very great. In this way one can compensate for the lack of beaming by the radio telescope by narrowing the frequency bandwidth of the signal. A small transmitter can create just as great a signal-to-noise ratio, or signal detectability, in a narrow band as would be created on a wider bandwidth by a gigantic transmitting facility.

Dragging the Sky for Signals

This hypothesis, which leads to the assumption that we must detect a signal of narrow bandwidth, greatly increases the number of frequency channels which must be searched. More importantly, because of the laws of physics, we must assume under this hypothesis that information can be transferred only very slowly. It can be shown that, with a given transmitter power, the max-

imum rate of information transfer is just proportional to the reciprocal of the fraction of the sky to which the signal is sent. To give a numerical example, if the width of the transmission channel is only 1/1,000 cycle per second, a minimum of a 1,000 seconds is required to transmit any information at all. This may seem remarkably slow to us, but to the immortals it would seem the obvious way to go. It is entirely conceivable that the premier form of interstellar message consists of an extremly narrow-bandwidth transmission, perhaps only 1/1,000 or 1/10,000 cycle per second wide, which changes in intensity or polarization, or in some other way, only in times of the order of hours.

There are natural limitations on the minimum bandwidth of interstellar signals, the result of clouds of interstellar gas containing a few electrons per cubic centimeter meandering across the lines of sight between civilizations. As these clouds cross the line of sight, the path of the radiation is slightly altered, with the result that the source appears to be moving toward or away from the receiver. Thus a tiny doppler effect is introduced. This changing doppler effect causes a drift in the signal frequency, limiting the minimum bandwidth. Numerically these drifts are terribly small, and they allow signal bandwidths of the order mentioned above.

All of the S.E.T.I. searches so far have used bandwidths so great that their sensitivity to the signals of the immortals was probably only 1/1,000 of what is achievable with available equipment. Narrower bandwidths have not been used because the experimenters wanted to search some appreciable part of the universe within a short available time. With narrower bandwidths of the order of 1/1,000 cycle per second, the number of frequency channels which must be searched to cover a reasonable part of the radio spectrum is some 10^{13}. No one has yet had the courage or the equipment to attack such a formidable number of possibilities.

Unbounded Possibilities for Good and Evil

I fear we have been making a dreadful mistake by not focusing all searches — including those to be accomplished by a system such as Cyclops — on the detection of the signals of the immortals. For it is the immortals we will most likely discover.

I have already given one reason why we should expect them to be abundant as message transmitters. But there is another independent argument which calls for the immortals' signals to be in the numerical majority.

It has been said that when we first discover other civilizations in space we will be the dumbest of them all. This is true, but more than that, we will probably be the only mortal civilization. Why is this?

We understand full well that our galaxy is a continuously evolving system producing new intelligent civilizations at nearly a constant rate. Indeed, the rate of production of new civilizations has been estimated at about one per year, including civilizations that remain mortal as well as those which achieve immortality. Mortal civilizations probably do not remain detectable forever, because their increasing technical sophistication enables them in time to cease the release of energy to space and thus to become undetectable. But some immortals must continue to transmit for cosmic time intervals, for the reasons given before. The number of either type of civilization at a given time is very simply the rate of appearance times the average longevity of civilizations. We think most intelligent civilizations become immortal, but even if this were not true and immortality were achieved only occasionally, the product of that rate times a nearly infinite lifetime will give a total number of immortals far greater than the population of all detectable mortal civilizations. So it is likely that immortals will dominate space. We should therefore concentrate our search on their signals, the narrow-band signals described above. We must pour some new wine into the old bottles of those who design searches for extraterrestrial intelligent signals.

Excerpts from the future of a science:

It is the year 1996. On the boiling Mojave Desert, row upon row of antennas have been scanning the sky for almost a decade. Computer programs, long since optimized, grind on day by day, only occasionally calling attention to a suspicious power level in a certain radio channel. Until today, each of the countless checks of the suspicious celestial positions and frequencies has shown the power to originate from earth, terrestrial signals which have evaded the intricate interference protection devices in the computer's receivers. But now a signal is received from a direction fixed among the stars. Its frequency never changes. Thus, it must be of artificial origin. Its creator has corrected for the doppler shift at the orbital motion of the object from which the signal comes. Only now it is noticed that every ten minutes the phase of the electrical vector which describes the signal is precisely inverted.

This is absolutely conclusive evidence of the intelligent origin of the signal. The signal is carrying a message in binary code, a message that will be received for a year before the scientists understand the format of the message and recognize it as the song of people who have been alive, every single one of them, for a billion years. They are sending the information which will make this same immortality possible for all the creatures of earth.

As never before, the people of earth now hold their destiny in their own hands. Should they adopt a life of immortality, thus causing a shattering transition in human life so great that its consequences are hardly predictable or imaginable? Or should they cling to death as well as their heritage of all that is good in human life? Should they cease their search of the skies and prohibit forever the reception of the monotone song of the immortals?

It is the year 2030. The humans remaining on earth . . .

References

Oliver, B. M., and Billingham J., *et al,* "Project Cyclops," National Aeronautics and Space Administration, Publication CR-114445, 1972.

Ponnamperuma, C., and Cameron, A. G. W., *Interstellar Communication: Scientific Perspectives,* Houghton Mifflin Company, Boston, 1974.

Sagan, C., ed., *Communication with Extraterrestrial Intelligence,* M.I.T. Press, Cambridge, 1973.

Sagan, C., and Drake, F. D., "The Search for Extraterrestrial Intelligence," *Scientific American,* 232, May, 1975.

Frank Drake is Director of the National Astronomy and Ionosphere Center, which operates the Arecibo Observatory at Arecibo, Puerto Rico. He is also Goldwin Smith Professor of Astronomy at Cornell University. He received his bachelor of engineering physics from Cornell University and advanced degrees in astronomy from Harvard University. Before going to Cornell he was associated with the National Radio Astronomy Observatory and the Jet Propulsion Laboratory.

Science museum exhibits are conceived to enrich our vision of the unity of scientific experience

Frank Oppenheimer
Director
The Exploratorium

Everyone Is You . . . Or Me

In my youth I used to wander in the mountains. I would gain a "feel" of the terrain and gradually build up a reliable intuition of how to get from here to there and back again. Always, on these expeditions, I would discover special places — a tiny area, the only one, where fairy slippers grew; a pool in a rushing stream that was deep enough to swim in. Invariably I would find myself excitedly climbing some promising knoll or uppermost peak. Suddenly a whole new vista would open up, showing a great expanse of prairie, a hidden lake in some inaccessible canyon, an entire new ridge of peaks.

As a result of these solitary expeditions, I would tell friends what I had found and would want to show it all to them. Somehow it was especially important that they see the view, often at a special time of day — perhaps precisely when the sun was setting. But we would start late or they would be unable to walk as fast as I. I would point to the place where I had found the fairy slippers, but we would walk on by. We would reach the top, and the view would be well worth the effort and the hurry. But gradually I began to realize that there was something wrong with these revisiting expeditions. Although the view far outweighed anything along the way in wondrous and memorable experience, the events along the way had been an integral part of the trip for me, and would also have to be so for the people I wanted to bring pleasure to. If the trip was spoiled through hurry or painful effort, then no one was moved to go searching for views on his own.

When I was teaching physical science to high school students, I felt the same kind of thing happening. The course was certainly an improvement on my mountain expeditions. It cleared the trail, mapped out switchbacks when the grade was too steep, and built bridges or steps when the terrain was impassable. But for those who built the course and came to know it well, it was crucial to reach the panorama of the final chapters, which put together everything that had gone before and opened up grand new vistas. From the vantage point of Bohr's model of the atom, one could look down and see where one had come from and how different and tiny everything looked down there. One could look out at new terrain that begged for future exploration. But in order to reach the vantage point soon enough, the trip had been spoiled. There was no opportunity to explore unexpected and pleasant nooks along the way.

The Exploratorium — or any good museum — is a response to the problems that beset both my guided tours in the mountains, and teachers who feel they must "cover the ground."

At the Exploratorium we've invented a new style of exhibit to do it.

Interchangeable Links in Common Chains

Consider our audience as contemplating a tree. Science museums all describe themselves as having interactive, involving, hands-on exhibits. But they misunderstand the implication of the terms they use. A tree has no pushbuttons, no cranks, no manipulative parts; but there are a lot of ways of interacting with it. One can look at it, lie under it, climb and feel it. One can watch the leaf buds unfold, mature into deepening greens and then oranges and reds until they fall off. One can study the bark, the cambium layer, the root hairs; extract sap; learn about photosynthesis. One can hear the rustle and watch the swaying in the wind. One can draw or photograph the tree, carve initials on it, chop it down, or just stand and watch the sunlight diffract around the edges of the leaves. One can even learn its name.

Our exhibits do not have quite this versatility. For one thing, we do not want people to chop them down; for another, the time scale is more defined: at most, half an hour at any one exhibit piece, often much less. More importantly, however, we conceive most of our exhibit pieces as props to link a pedagogical chain; frequently the links are common to several different chains. Thus, the Relative Motion Swing, which has a swinging table beneath a pendulum of the same period, can be used in many contexts. One can use it in talking about vectors, about polarized light, about Lissajous figures, about phase, amplitude and frequency, about damping, about kinetic and potential energy, about frame of reference and relative motion. For each of these topics this exhibit is but one link shared by several other chains of exhibits, which may intersect at other links as well.

The fact that we use this exhibit for these multiple but specific purposes limits the versatility of people's interactions with it, but not as severely as one might imagine. True, visitors cannot disassemble and rebuild the exhibit. True, we have not made provision for the visitor to vary

An exhibit of the scale and beauty of the Sun Painting — the work of San Francisco artist Bob Miller — is "crucially important" for a science museum, says Frank Oppenheimer, Director of San Francisco's Exploratorium. The scattering of sunlight through a series of prisms paints colors onto a giant screen — "a brilliant abstract painting that shimmers and changes as people move in the light path and brush against the Mylar mirrors behind the screen," writes Dr. Oppenheimer. (Photo: Ron Hipschman)

Why is the Relative Motion Swing — a swinging table beneath a pendulum of the same period — such a good exhibit? Because it can be used in so many different ways, writes its designer, Frank Oppenheimer — an exhibit for everybody, including this girl watching how the pendulum can draw a circle while in straight back-and-forth motion. (Photo: Ron Hipschman)

the swing periods of the table or the pendulum. (The clearest pedagogy arises when the two motions swing synchronously. If either were readily adjustable, most visitors would not take the time to make the two motions synchronous and thus would not perceive the most delightful effects of relative motion.) On the other hand, we have not designed out all possibilities of variation. Although the pendulum swings most readily at right angles to the table, it can also swing parallel to the motion of the table with a very different and not commensurate period. The table itself can be made to vibrate perpendicular to its swing and, thereby, modulate the basic pattern of relative motion.

People use this exhibit in many different ways. Some just give the table a push as they walk by — but then, so do I. Others make everything move every which way producing a noisy, unintelligible relative motion pattern. I enjoy doing that too. Many people very systematically let the table and the pendulum swing at right angles to each other, trying to reproduce the indicated circles and diagonal lines of relative motion, learning about relative phases and amplitudes by trial and error. There are some visitors who know all about what the pendulums are "supposed" to show. They use the exhibit to instruct their friends and children — and I also use it that way.

This is a very good exhibit. I enjoy playing with it myself, and I enjoy showing it to you — no matter who you are; it is an exhibit for everybody. Many decisions went into its construction. It is versatile; visitors can find systematic things to do with it with relative ease; and one can obviously invent activities that are "out of context," clearly not part of any preconceived syllabus. The exhibit has other virtues as well. It is made entirely of hardware-store parts: pipe, perforated angle iron, cable and turnbuckles, springs, etc. The hinging involves a short section of pipe rolling on two rods for the proper motion of the pendulum and a rocking motion from one rod to the other for the playful motions. The main defect in the exhibit is that, although there is elegance in the design, there is virtually none in the craftsmanship. Perhaps it was built in too much of a hurry.

In contrast to the relative motion pendulum, our exhibit demonstrating the magnetic force on a wire carrying a current is a very poor one. We placed three exceptionally large permanent magnets to have a common poleface, making a horizontal rectangular magnetic field, 10 inches deep and 2 inches high, with a gap of about 2 inches. A thick wire carries about 250 amperes, triggered when a visitor steps on a mat switch. The wire is hinged so that a straight length of wire can move up and down through the magnetic field. When the current is turned on, the wire pops up through the field, and the visitor who tries to push the wire down feels the large, springlike force of opposed magnetic fields. One can even "feel" the current because of the imperfectly smoothed direct current. A good deal of thought went into the design and execution of the exhibit, and it forms an important link in a series of exhibits on electromagnetism. But it shows only one thing. When I demonstrated the piece to one of our staff members, she said, "The lid of my garbage can pops up when I step on the foot lever, too."

This exhibit is a traditional science museum demonstration. It may even be a little better than most, because the magnet and the wire are out in the open and not behind glass. I frequently use the exhibit as a prop for teaching electromagnetic phenomena, but I never play with it as I walk by or show it to friends who visit the Exploratorium. It is not for me — it is not for you, it is for nobody. No side effects branch from the main phenomenon that it demonstrates. It just does what it is supposed to do; there is no way to make it misbehave. It does not even contain any redeeming features of beauty or whimsy. Too much was designed out of the exhibit. In order to let people feel how strong the force is, the magnet was made strong; it would, therefore, have been dangerous to leave any loose pieces of iron around. The wire is large and stiff in order to carry the 250 amperes without growing hot. It is a single twisted bundle of wires and not a loose collection of flexible ones because a loose collection would have gone every which way and become tangled on the polefaces. We were too timid (or not clever enough) to use such a messy array of wires. We used a permanent magnet rather than a variable electromagnet because we thought the exhibit would thereby be conceptually more obvious. Thus, one by one, we designed out any and all the features that might have made the exhibit worth spending some time with. We converted the tree into a telephone pole.

Although the best exhibits commonly link several intersecting chains of ideas, this property is not essential. The Bernoulli Blower is a case in point. Here, a large blower has a truncated rubber highway marker mounted on top of it. The air stream supports a light-weight volley ball. The Bernoulli effect is strong enough so that one can feel an appreciable inward force if one tries to pull the ball out of the stream. People tap the ball and watch it oscillate in the stream; they partially cover the orifice with a hand or direct the stream to one side; they remove

the ball and try to throw it so that it is caught by the stream. But they also do completely irrelevant things. Girls let their long hair stream up in the air current; kids hold their T-shirts over the orifice and let the air stream cool their bellies. Some people play catch with the ball either through or around the air stream. We lose about 25 balls a year — one per 20,000 visitors. If the ball is missing, people tear up bits of paper and see how these behave in the air stream. It is a pretty good exhibit, but we should build more links in this particular chain.

I cannot really say that I have noticed any difference in the way visitors to the Exploratorium behave on sunny and cloudy days. But for the staff and especially for me, and my feeling for you when you come to visit, whether the sun is turned on or not makes an incredible difference. This is because of the Sun Painting. I think it crucially important to have an exhibit of such scale and beauty. A beam of sunlight comes through a skylight from a sun-following mirror to illuminate the dusty gloom at the north end of the building. It strikes an angled flat mirror which sends it parallel to the floor into an array of vertical prisms; a multitude of vertical strips of mirror then pick up each individual spectral color, directing each color first behind and then onto an eight-by-fifteen-foot frosted screen. The exhibit demonstrates light scattering, prisms and mirrors and color, and sunlight. It is a brilliant abstract painting that shimmers and changes as people move in the light path and brush against the mylar mirrors behind the frosted screen. We have other exhibits of beauty, and without them the museum would be sterile and incomplete; but none are so fine as the Sun Painting. Not all the exhibits in the museum need to be of great beauty, but surely some must be, or the place would be for nobody.

The Benefits of Overkill

The attributes of exhibits that I have described — their beauty, their multiple linkages with different themes, the inclusion of extraneous possibilities for intervention and discovery — have proved to be important to the overall effectiveness of the museum. There are other general practices that are important. In particular, when we make an effort to illustrate some process or behavior that is pervasive in nature (refraction, resonance, or sensory lateral inhibition, for example), this behavior is presented in many exhibit pieces. Each illustrates the same underlying process in very different contexts. For example, wave motion is a powerful abstraction that could not be perceived from any single type of wave. But the concept can take shape by observing the effect of light waves and water waves and sound waves, of waves on an oscilloscope, and waves in a string or a flat plate. Some of our exhibits on waves are grouped together as a sub-section in the museum. Many of them are scattered in various other topical sections of the museum.

Even phenomena less pervasive than waves need multiple and varied examples so visitors can develop an intuitive understanding. We have three exhibits on stroboscopic illumination, and plan several more. There are at least half a dozen on spatial and temporal beats, but we still need simpler and clearer exhibits on this topic. We have two dozen exhibits about the perception and mixing of color, and well over a dozen different ways to involve people in the basic phenomena of depth perception through binocular vision. One of the great virtues of museums stems from the possibility that visitors can, by themselves, achieve a very satisfying understanding through abstraction from multiple and contextually different examples. Many museums fail to provide this possibility because they show only a single representative example of each effect or process.

A Different Drum to Demonstrate Resonance

The basic problems of exhibit design are not solved by the general considerations that I have outlined. Each effect, each idea, each way of conceiving some aspect of nature requires a topic-specific design. One sees the need for an exhibit — that is, one is aware of a crucial link that is missing at the beginning or middle or end of some topical chain. The need may become apparent while teaching our aides or in conducting some of the formal classes here. Frequently this need festers for a year or more before someone on the staff or a visitor suggests a reasonable way of forging the link. In the meantime one continues to fabricate less crucial links in the chain.

For example, we have been developing many exhibits on optical and acoustical resonance, but we have not figured out how to show, clearly and convincingly, what goes on when a non-resonant device, like a bow, excites a resonant violin string. We are getting closer. We increased the weight of the rope that is stretched across the 120 feet of the museum so that when the visitors jerk the rope they can feel the reflected pulse pull on their hand a moment later. We have a series of different length glass pipes, each of which responds, like a seashell held to the ear, by selecting and resounding a characteristic note out of the ambient noise of the museum. We have a 400-pound pendulum that visitors can put in motion only

In the Exploratorium's Bernoulli Blower the air stream from a powerful blower supports a light-weight ball, and museum visitors can feel the forces on the ball and watch it move as the air stream is changed. They can also do "completely irrelevant things," says Dr. Oppenheimer — a fact which worries him less than the problem of making the Blower exhibit "link more intersecting chains of ideas." (Photo: Ron Hipschman)

by pulling repeatedly and at the proper time on a cord that is very weakly attached to the pendulum by a small magnet. We are building an Aeolian harp. All of these exhibits work around the edge of the basic phenomena, but we still do not have anything to show how the rubbing of a bow or the hissing of a stream of air is converted into a sustained tone in a musical instrument.

We are planning other links in this resonance chain. We know roughly how to demonstrate the resonance absorption of yellow light by sodium vapor, but we have not yet managed to develop this important exhibit. On the other hand, we have not yet decided how to convey what is going on in a resonant electrical circuit. Perhaps, after we have built more links in an electrical phenomena chain, a method for this particular demonstration will occur to us. There are no general prescriptions for exhibit design that will solve this problem. Yet it is precisely on the success in finding such solutions that the quality of science museums depends.

Addiction to Individual Discovery

A museum's logistics force its staff to have flexible teaching strategies. Conducting a group tour is impossible. It is also impossible, even if one wished, to insist that visitors work with the exhibits in a prescribed order. In a crowded museum, the visitor may not be able to progress to the "next step" because other people are in the way. Even people who come together take separate paths and then call to each other, "Hey, come look at this!" When staff members are frustrated by our visitors' tendency to this kind of "Brownian motion," I urge them to look back and remember how many different kinds of patterns and circumstances in their own learning were wonderful — like the variety of my mountain walks.

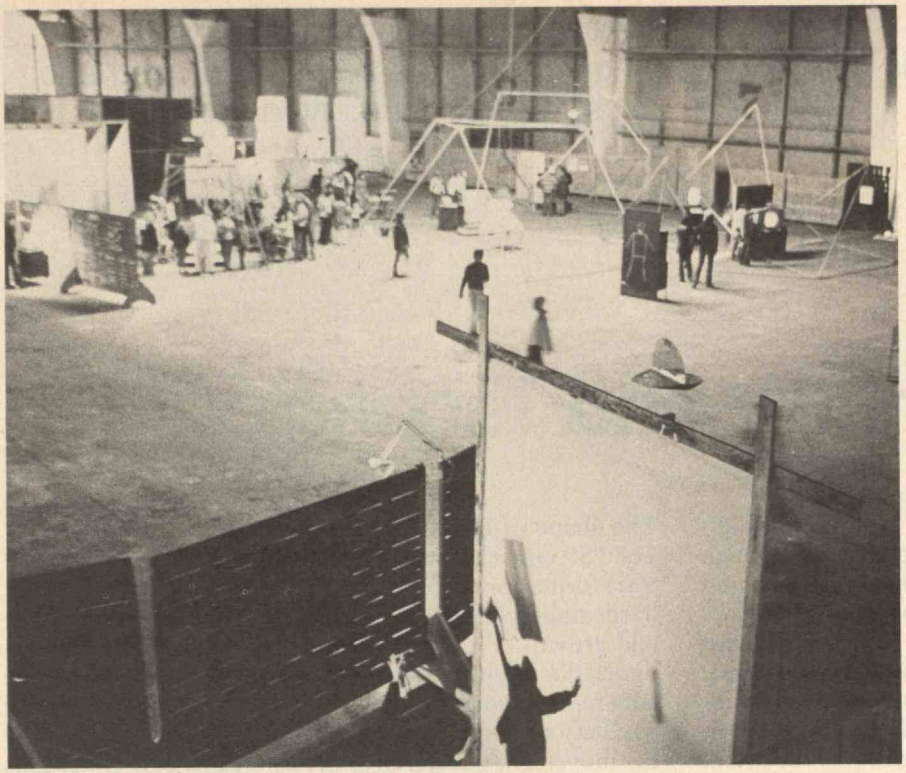
The character of our visitors' exploration of the museum is the main reason for our having aides — we call them Explainers — moving around the floor, stopping to play with or fix one of the exhibits. (Any attempt to repair an exhibit invariably draws an eager group.)

The difficult problem for the staff is how to show our visitors the path leading to the broader vistas and the sense of unity and coherence that one would like them to perceive and which, to a large extent, they would like to find.

The remarkable feature of the process of individual discovery, whether of detail or of generality, is that the first taste of success can be addicting. For some obscure reason we, as teachers, are committed to turning on addicts. But potential addicts are not programmable; one never knows who they are or when they are vulnerable. We argue among ourselves: if we do not tell people what they are supposed to find, many will leave with a sense of frustration, but a few will have become addicted to finding more than anybody knew was there. How many frustrated people is one addict worth? Since there is no going back if one gives away too much, we tend to lean toward the more radical answer to this arguable question. And we do have a large number of addicts who come back for more.

For the many who feel somewhat frustrated because their curiosity has been aroused but not satisfied, we have persuaded ourselves that we can enrich the museum experience by preparing written, take-home material related to our exhibits. In addition, we should be able to make short topical television programs which use our exhibits as props. The broadcast programs would not be for national distribution but would help people who had visited the museum and who planned to return. We also sell relevant books and reprints in the museum store. This reliance on take-home written material may seem to be a cop-out from the task of designing better exhibits. There is, however, no valid reason for rejecting the abundant use of language, especially if the language is based on the kind of broad experience that people can find in the Exploratorium.

We are careful not to be overly wordy in the signs that accompany the exhibits, but, in fact, we have not adequately solved the problems associated with exhibit graphics. Too many words can be intimidating and can discourage people from trusting their own ability to explore and find things out for themselves. It is also true that words can be used to fool people into believing that they have been enlightened. For example, concerns about consumer protection have led to legislation that requires the ingredients to be specified on medicinal labels. As a result, the disinfectant spray, Bactine, for example, has an unenlightening label that reads: "Alcohol 3.17 per cent, Methylbenzethonium chloride, isooctylphenoxypolyethoxyethanol and chlorothymol." Why should not this information be given in a pamphlet explaining which ingredient serves as bacticide, which as fungicide and which as deodorant? It could even explain why these particular organics are effective, painless, and commercially protable. Museum curators invariably complain



"Discovering the Exploratorium is like stumbling into the belly of a giant whale where some mad scientist has found a home," writes its director, Frank Oppenheimer. The museum's unlikely home is the cavernous Palace of Fine Arts in San Francisco, originally created for the 1915 Panama-Pacific International Exposition. In 1969 Dr. Oppenheimer set out to create there an institution that would make science and technology more accessible to the public — "a place where people could not only learn but participate." Now the asphalt floors feel the footsteps of 400,000 visitors a year, and the concrete walls resound to a public invited in "to touch, pound, open, pull on, look through, listen to, screech at, and climb through."

that the public does not read. But I see no reason for a museum to cater to the fact that many people have been put off language by the way it is so deliberately used with dishonesty in commercial and political life.

At Ease with Trivia in a Non-Trivial Place

The Exploratorium is a good museum because of the care and thoughtfulness with which the exhibits have been conceived, designed, and assembled. But many of the people who visit us stress, and perhaps exaggerate, the importance of the general ambience of the place. Some aspects of this ambience may be essential to our purposes. The remarkable spaciousness of the Palace of Fine Arts hall is certainly unique. It is also vital that we do not fragment the space with walls that define subject matter boundaries. Since we want visitors to explore and invent in a way to which they are unaccustomed, we avoid the usual plethora of written and verbal commands as to how they should behave. We also resist making rules whose sole purpose is to reduce the amount of work or decision-making required of the staff.

The most important aspect of the ambience of the Exploratorium may stem from the fact that visitors are never subjected to judgmental discomfiture. They do not feel compelled to decide whether they are supposed to learn something from an exhibit or merely to enjoy themselves. If they stand before an exhibit and say, "Gosh, my eight-year-old child could do that," this remark is made approvingly. It is not the familiar disparaging or derisive statement that is heard in an art gallery. Nothing in the setting, label, or symbolism suggests to the visitor that he must decide whether an exhibit is truly great art or great science or an outstanding intellectual achievement of the human mind. It is in this one respect — and only in this one — that we may conceivably fool people, because many of the things they look at really do reflect the extraordinary quality of somebody's achievement and imagination.

Even in this respect, though, I doubt that we really fool people. They are certainly aware that the Exploratorium is not a trivial place. But we do nothing that would make people feel uncomfortable with non-triviality; else why do so many teachers bring students, why do so many students bring back their parents and families and friends? And why would those few adults who come alone invariably express regret that they do not have their children or grandchildren with them?

I suspect that everybody — not just you and I — genuinely wants to share and feel at home with the cumulative and increasingly coherent awareness of nature that is the traditional harvest of scientists and artists.

The exhibits that we have designed, the thematic emphasis on perception and the general atmosphere of the Exploratorium, go a long way toward making this sharing possible for an indescribably diverse population. There is a great deal left to do and learn in order to complete what we have started. As we mature it also seems ever more important to us that we learn how to integrate what happens here with learning and enjoyment that takes place at home, in the city and country, and in schools. In the meantime, it is wonderful and rewarding to just wander around the floor, watching, listening to, and occasionally talking to the visitors. Perhaps each of us is in some way everybody, and the surest way to delight others is to find what is a delight to ourselves and to the people we are fond of.

Frank Oppenheimer's career in physics has been as varied as the museum over which he now presides. He studied at Johns Hopkins (B.A. 1933), the Cavendish Laboratory in Cambridge, England, and the California Institute of Technology (Ph.D. 1939); worked for the Manhattan Project during World War II; taught physics in Colorado high schools in the late 1950s before joining the University of Colorado faculty, and in 1969 founded the Exploratorium. Since then this museum has grown to receive some 400,000 visitors a year and to have an international reputation as an innovative educational institution in the field of science.

Cyril Stanley Smith
Institute Professor, Emeritus
M.I.T.

History shows that technology originated far more often in aesthetic urges than in perceived usefulness

On Art, Invention, and Technology

Nearly everyone believes, falsely, that technology is applied science. It is becoming so, and rapidly, but through most of history science has arisen from problems posed for intellectual solution by the technician's more intimate experience of the behavior of matter and mechanisms. Technology is more closely related to art than to science — not only materially, because art must somehow involve the selection and manipulation of matter, but conceptually as well, because the technologist, like the artist, must work with many unanalyzable complexities. Another popular misunderstanding today is the belief that technology is inherently ugly and unpleasant, whereas a moment's reflection will show that technology underlies innumerable delightful experiences as well as the greatest art, whether expressed in object, word, sound or environment.

Even less widely known, but important for what it tells of man and novelty, is the fact that historically the first discovery of useful materials, machines, or processes has almost always been in the decorative arts, and was not done for a perceived practical purpose. Necessity is *not* the mother of invention — only of improvement. A man desperately in search of a weapon or food is in no mood for discovery; he can only exploit what is already known to exist. Discovery requires aesthetically-motivated curiosity, not logic, for new things can acquire validity only by interaction in an environment that has yet to be. Their origin is unpredictable. A new thing of any kind whatsoever begins as a local anomaly, a region of misfit within the preexisting structure. This first nucleus is indistinguishable from the few fluctations whose time has not yet come and the innumerable fluctuations which the future will merely erase. Once growth from an effective nucleus is well under way, however, it is then driven by the very type of interlock that at first opposed it: it has become the new orthodoxy. In crystals undergoing transformation, a region having an interaction-pattern suggesting the new structure, once it is big enough, grows by demanding and rewarding conformity. With ideas or with technical or social inventions, people eventually come to accept the new as unthinkingly as they had at first opposed it, and they modify their lives, interactions, and investments accordingly. But growth too has its limits. Eventually the new structure will have grown to its proper size in relation to the things with which it interacts, and a new balance must be established. The end of growth, like its beginning, is within a structure that is unpredictable in advance.

The Shape of Universal History

The "S" curve on page 38 (adapted from a paper on the transformations of microstructure responsible for the hardening of steel) can be used to apply to the nucleation and growth of anything, *really* any "thing" that has recognizable identity and properties depending on the coherence of its parts. It reflects the underlying structural conflicts and balance between local and larger order, and the movement of interfaces in response to new conditions of components, communication, cooperation, and conflict.

Applied to the growth of either individual technologies or to the development of whole civilizations based upon interactive technologies, the "S" curve reflects origin in art, growth in social acceptance, and the eventual limitation of growth by interactions within a larger structure which is itself nucleated in the process. The conditions of beginning, development, and maturity are very different.

Though a computer program can duplicate such curves, it is only by looking at the whole hierarchial substructure and superstructure that intuitive understanding can be gained. All stages involve a balance between local structure and overarching regional restraints. All change involves a catastrophic change of connections at some level while topological continuity is maintained, though perhaps with strain, at levels both above and below. Human history follows the same general principles of structural rearrangement as a phase change in a chemical system, though most teachers of history ignore the nucleating role of technology and concentrate on the social changes that are engendered by it.

The transition from individual discovery and rare use of techniques to the point where they affect the environment of Everyman and the content and means of communication between people and peoples underlies virtually every great social or political change and every fundamental change in man's view of the world. Few general histories reflect this. An understanding of the proper place of technology within the whole human experience is desperately needed in order that society can wisely decide what to develop and what to discourage. Technology needs to be seen in the perspective that humanists have traditionally applied to man's other activities. Personally, I believe that the life of a craftsman, indeed of any man making something to be enjoyed or used, is a fine example of what it is to be human: mind, eye, muscle, and hand interacting with the properties of matter to produce shapes reflecting the purposes and cultural values of his society, and sometimes extending them.

The verbal records conventionally used by the historian

Greek statue of Poseidon. Bronze, 475 B.C. The statue was cast in several parts by the lost-wax process, and the parts were joined together by running in superheated molten metal of the same composition, as shown in the accompanying photograph

taken by Arthur Steinberg. For many centuries welding was used only in sculpture, though it is now an essential step in the construction of most machines and large structures. Courtesy National Museum, Athens.

reflect this very poorly indeed. Conversely, works of art, when seen at every level from the atom to the whole, provide excellent records of almost everything about man. Usually they are enjoyed for their outer form and symbolism alone, and appreciated as a statement of the artist's ideas on some aspect of the world, an expression of the forms and feelings that he selectively absorbed from the culture of which he was part. However, his work is also an object and as such a product of technology. Thus, the famous bronze statue of Poseidon above involves technology both submerged in the emotional and cultural meanings carried by its glorious form, and also more tangibly in the actual operations of smelting, alloying, casting, and welding that produced it. The techniques had themselves developed through earlier (non-Greek) history and they were to have an influence on the subsequent development of the Western world comparable, in my view, with that of Greek ideas in aesthetics and philosophy.

Historians of science, while properly emphasizing the development of unifying concepts, commonly overlook the fact that thoughtful intimate awareness of the properties of matter first occurred in the minds of people seeking effects to be used decoratively. Both Democritus' atoms and Aristotle's elemental qualities are expressions of what the philosophers could have observed on a stroll down Hephaestos Street, noting the changes in strength, plasticity, texture and color produced by the treatment of materials as the artisans shaped things for their customers. Similarly the multi-valent game tokens found in very early excavated sites in the Middle East as well as the space-filling interlock of features in decorative pattern must have some place in the earliest history of mathematics.

Archaeologists and art historians, of course, long ago learned to interpret human experience from the evidence of artifacts. But even they have concentrated upon iconographics and styles, on ideas external to the object,

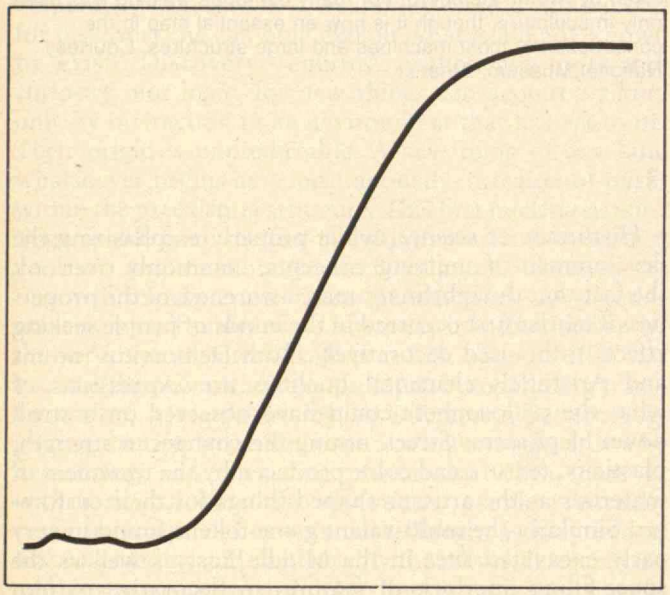
and only occasionally have they sought to understand the technical experience in its production. Yet in making a work of art, a man must select material having a "nature" that will conform to the larger shapes that he wishes to impose upon it. There is a continuous hierarchy of interactions: the object stands at the very point where the structures and properties of matter resulting from forces between atoms are in visible interaction with man's ideas and purposes. An artist's work preserves a record of both — one in the outer form and decoration, the other in the texture and color and fine contours that result from the interplay of atomic, molecular, and crystalline forces. The texture continues downward into a rich microstructure: hierarchical patterns of atomic order and disorder that change in recognizable ways as matter is subjected to thermal and mechanical treatment in its compounding and shaping.

Everything complicated must have had a history, and its internal structural features arise from its history and provide a specific record of it. One might call these structural details of memory "funeous," after the unfortunate character in Borges' story "Funes the Memorious" who remembered everything. The aim of respectable science through most of history has been to study afuneous details; it has been analytic, seeking the parts or ideally simplified wholes. Analysis is, of course, absolutely essential for understanding, but no synthesis based upon it can reproduce the funeous structures that provoked interest in the first place unless the essentials of their individual histories are repeated. History selects and biases statistics. The particular structures that do exist, however improbable they may be, must be given priority in man's studies. The messier sciences such as old-fashioned biology or my own metallurgy have always been concerned with complex structures, and they have emphasized the relation between real structure and properties, while the pure sciences have perforce avoided that which was structure-sensitive, and hence funeous. At least until very recently: now, however, the material sciences have merged with solid state physics and are showing how to study real structure with a wholly new emphasis upon imperfections in atomic order. Dissymmetry rather than symmetry is seen to be the key to many marvellous new materials — though dissymmetry is invisible except in a matrix of symmetrical order. New methods capable of revealing the whole structure at all levels have been developed — thereby incidently opening a new level of funeous record for study by historians.

The Origins of Techniques

The figures on the opposite page each show an antique bronze object and its structure as seen under the microscope. The microstructures differ more from each other than do the external forms — and they instantly reveal to a knowing eye the technical history of making the object. Such records are in a universal language, and they are free from the distortion that inevitably accompanies passage through a human mind. Through such records, I have communicated with dozens of craftsmen, including a Luristan smith of 800 B.C., a bronze founder of Shang China, an ancient Greek goldsmith, and a 13th-century Japanese swordsmith; and I have understood them better than I understand some of my English-speaking colleagues today! This newly-found Rosetta Stone is making accessible records of a new world, or more correctly, an unnoticed aspect of culture in the old. As a metallurgist trying to understand the history of his profession, I had exhausted the literary sources without finding evidence of the beginnings of most of the techniques that interested me: only when I moved from libraries to art museums did I find the real origins of metallurgical (and other) techniques, and in doing so my whole view of man, matter, and discovery changed.

Practical metallurgy is seen to have begun with the



Curve depicting the beginning, growth, and maturity of anything whatever. Adapted from a paper on the hardening of steel, it is here used to show the beginnings of most branches of technology in the decorate arts, their industrial growth in response to a social demand, and their maturity in conflict and balance with other things. Both the beginning and the end depend on highly localized conditions and are unpredictable in detail.

A Cast bronze ceremonial vessel, type Ting. Chinese, Shang or early Chou dynasty. 20.3 centimeters in diameter. This was cast in a clay mold made in several divisions. The different decorative details originate in different technical methods of treating the mold surface. (Fogg Art Museum, Harvard University, Bequest Grenville L. Winthrop)

B Microstructure of Chou dynasty bronze similar to that used in vessel **A**. The metal has been sectioned, polished, and chemically etched in order to reveal the complex pattern of the metallurgical microconstituents. Magnified 250 times.

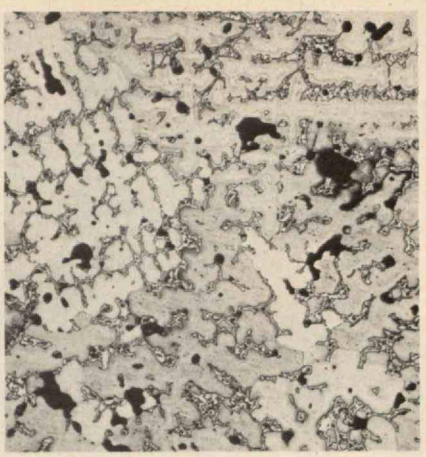
C Piece of bronze armor. Crete, ca. 600 B.C. This was made of hammered sheet bronze, about one millimeter thick, with repoussé decoration and wire-reinforced edges. Its width is 24.2 centimeters. (Norbert Schimmel collection)

D Microstructure of a cross-section of Cretan armor like that of **C**. This shows the grain structure corresponding to worked and annealed bronze, with elongated inclusions of slag and many "slip lines" indicating some final cold deformation. Etched. Magnified 200 times.

E Oval bowl of high-tin bronze. Iran, 7-8 century A.D. Made by hot forging, followed by quenching in water. Unlike steel, this alloy (22 per cent tin) is brittle if slowly cooled. (Metropolitan Museum of Art, Dr. Peter Meyers, Rogers Fund 1949)

F Microstructure of an Iranian bowl similar to that of **E**. The needle-like features are sections of plates resulting from a crystallographic change that occurred during rapid cooling. Etched. Magnified 500 times.

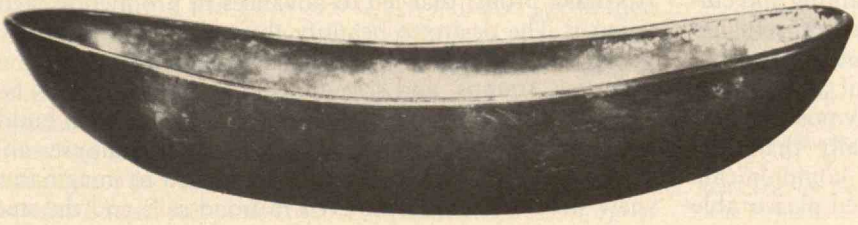
A



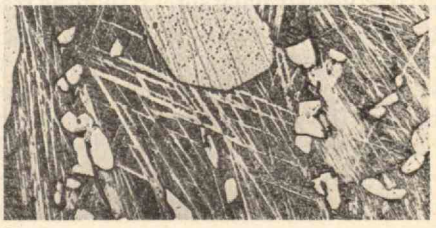
B

C

D



E



F

Statue of Prince Albert with four flanking figures of the continents. Made in electrolytic baths by Elkington and Company in 1862. The statue, a memorial of the Great Exhibition of London, 1851 is still to be seen in London, immediately to the southeast of Albert Hall. Our illustration is taken from the *Illustrated London News*, June 27, 1863.

making of necklace beads and ornaments in hammered native copper long before "useful" knives and weapons were made. The improvement of metals by alloying and heat treatment and most methods of shaping them started in jewelry and sculpture. Casting in complicated moulds began in making statuettes. Welding was first used to join parts of bronze sculpture together: none but the smallest bronze statues of Greece or the ceremonial vessels of Shang China would exist without it, and neither would most of today's structures or machines. Ceramics began with the fire-hardening of fertility figurines moulded of clay; glass came from attempts to prettily glaze beads of quartz and steatite. Most minerals and many organic and inorganic compounds were discovered for use as pigments; indeed, the first record that man knew of iron and manganese ores is in cave paintings where they make the glorious reds, browns, and blacks, while the medieval painter controllably used pH-sensitive color changes long before the chemist saw their significance. In other fields, archaeologists have shown that the transplanting and cultivation of flowers for enjoyment long preceded useful agriculture, while playing with pets probably gave the knowledge that was needed for purposeful animal husbandry. To go back even earlier, it is hardly possible that human beings could have decided logically that they needed to develop language in order to communicate with each other before they had experienced pleasurable interactive communal activities like singing and dancing. Aesthetic curiosity has been central to both genetic and cultural evolution.

Mechanical devices were less developed in the ancient world than were materials of comparable complexity. Perhaps this was because the aesthetic rewards of play with simple, and hence invariant, mechanisms are small. However, note that wheels first appeared on toys, and that the automata based on hydraulic and mechanical tricks that were used in Greek temples and theatres were the prelude to the waterwheel and the clock. The lathe reached an apex of ingenuity in turning guilloché snuff boxes more than a century before heavy industry used it. The painting of pictures preceded purposeful type, and the use of rockets for fun came before their military use or space travel. The techniques of casting bells, like the material of which they were made, were ready to be directed toward a different kind of sound and purpose when princes wanted cannon.

Enjoyment of color has inspired the development of many alloys — for example the famous Mycenean inlaid dagger in the National Museum in Athens, and the exquisite colored metal inlay of Japanese sword furniture. It is also related to the refining and purification of metals in early times because of the use of corrodants to change the color of native electrum. The color changes in metals, oxides, and sulphides discovered by far earlier artisans permeate medieval alchemy — a dead end of delightful but unproductive theory. The marvellous golds and blues of medieval illuminated manuscripts came from pigments made by processes that foreshadow modern powder metallurgy and the flotation process of ore separation. The desire for pigments, dyes, and cosmetics inspired much mineralogical and botanical exploration, while precious stones, dyes, spices, and jewelry formed the first base of commerce, for long range trade did not start with necessities. Even bankers were once goldsmiths. The chemical industry later grew from the need for quantities of mordants, bleaches and alkalies for use in the finer textiles and glass. Geology, chemical analysis, and high temperature research all took a leap forward in eighteenth-century Europe under the impact of the potter's efforts to duplicate the marvellous wares coming from the Orient, which had started the craze for chinoiserie. The great French scientist Réaumur made a cheap, crystalline "porcelain" by devitrifying glass, and he also developed malleable cast iron in his search for a cheaper substitute for the handsome chiselled wrought iron work on the gates of the chateaux of the aristocracy.

More Like Love than Purpose

In all of these cases, and many more that could be cited, it was aesthetic curiosity that led to initial discovery of some useful property of matter or some manner of shaping it for use. Although the maker of weapons was quick to follow, it was nearly always the desire for beauty or the urge to make art available to the masses (or, if you will, the desire to exploit mass desire for pretty things in order to make profit) that led to advances in production techniques. The desire to beautify the utilitarian has always stretched the ingenuity of the mechanic, who made drawbenches, stamps, and screwpresses to shape trinkets before automobile parts or weapons. It is the same in building construction: temples and churches, greenhouses and Crystal Palaces, not necessary shelter, led to imaginative new structural methods. Even railroad rails and the steel

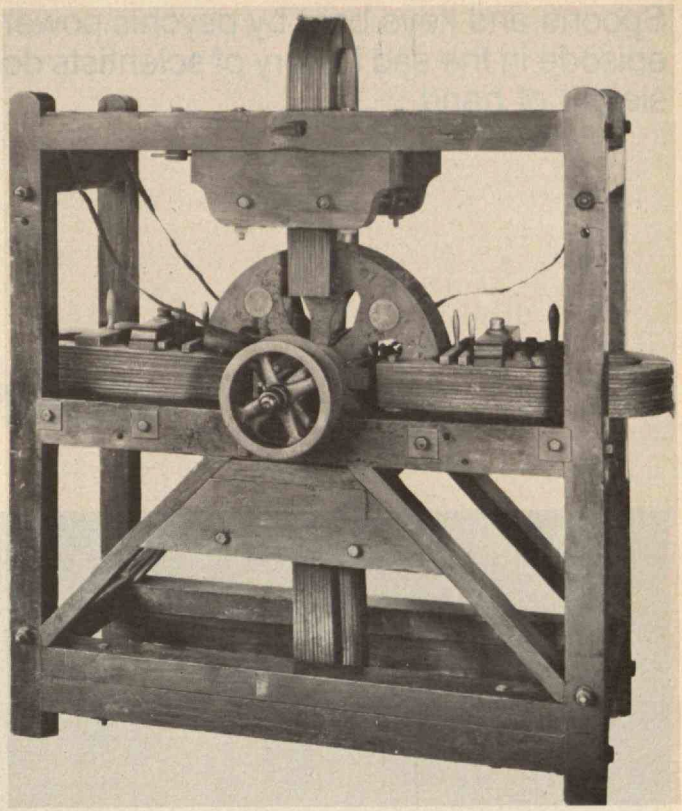
girders for today's skyscrapers needed a precursor in the form of the little mill that rolled lead cames to be used in medieval stained-glass windows, and it was a French gardener who invented reinforced concrete because he wanted a larger flower pot for more magnificant display.

In the 19th century the milieu of discovery began to expand. Science created a new environment in which imaginative curiosity could operate. Though the discovery of voltaic electricity could have come from metal-replacement reactions used in the arts or from the delightful philosopher's toy, the *Arbor Dianae* (an electrolytic tree of crystalline silver), it actually came from an unaesthetic experiment on a frog's leg. It remained unused until 1837, when the electric telegraph and electrotyping were both seen to be useful. The utility of the latter, however, at first lay only in the arts: it was used as a process for electrolytically duplicating coins, plaques, statuary, and engraved or etched plates for the graphic artist. All the great illustrated newspapers stem from this — the *Illustrated London News,* the *Scientific American, L'Illustration,* and *Harper's Weekly.* Soon electrolytic baths were giving rise to monumental sculpture, some weighing over 7,500 pounds. Many of the "bronzes" in the Paris opera house are of electrodeposited copper, while a nice English example is the ten and a half foot high statue of Prince Albert *(page 40)* behind Albert Hall in London. It was made by the firm of Elkington in 1863.

Almost immediately an even larger use for "galvanism" developed — the production for middle-class tables of metalware having all the glitter of the rich man's silver and gold. Within a decade, Sheffield plate was supplanted by electrodeposited silver plate, with a not always felicitous relaxation of restraint on design.

At first the electric current for these applications came from banks of small batteries (Daniell cells) in which nearly three pounds of zinc and acid were consumed for every pound of copper deposited. The larger uses of electricity could develop only after a steam-driven generator had grown out of an 1832 lecture-demonstration device made to intrigue physics students with the realities of Oersted's electromagnetic interaction. The illustration on this page shows the first commercial electrical generator. Constructed in 1844 to the 1842 design of J. F. Woolrich (whose patent includes also a plating bath), it was used in the shops of the Elkington Company for several decades before it was donated to the Birmingham City Museum, where it now stands. The giant electric power industry of today thus did not begin with a preconceived desire for its utility — the first suggestion came from the arts. Once power generation had been demonstrated, however, it was ripe for development and use by men of a different cast of mind; soon came lighting (beginning with arc lights for light-houses), and then motive power. All big things grow from little things, but new little things will be destroyed by their environment unless they are cherished for reasons more like love than purpose.

Banquo expressed a deep human wish when he asked the witches "If you can look into the seeds of time, and say which grain will grow and which will not, speak then to me." But how do the seeds of human achievement form in the first place? Not just by taking logical thought, but rather by giving curiosity full rein and using all of a human being's capability — his holistic powers of understanding and aesthetic imagination as well as his analytical skills. I do not mean to imply that all technologists are sensitive aesthetes, but I do claim that the *beginning* of much useful technology (as indeed of most human achievements in the past) has arisen in aesthetic experience. The subsequent and more obvious stages of profitable development can occur only as a sequel to a quite different dynamics.



Magnetoelectric machine for commercial electroplating. John Stephen Woolrich, designer, 1842. Thomas Prime and Sons, builder, Birmingham, England, 1844. The machine is 62.5 inches high. Museum of Science and Industry, Birmingham.

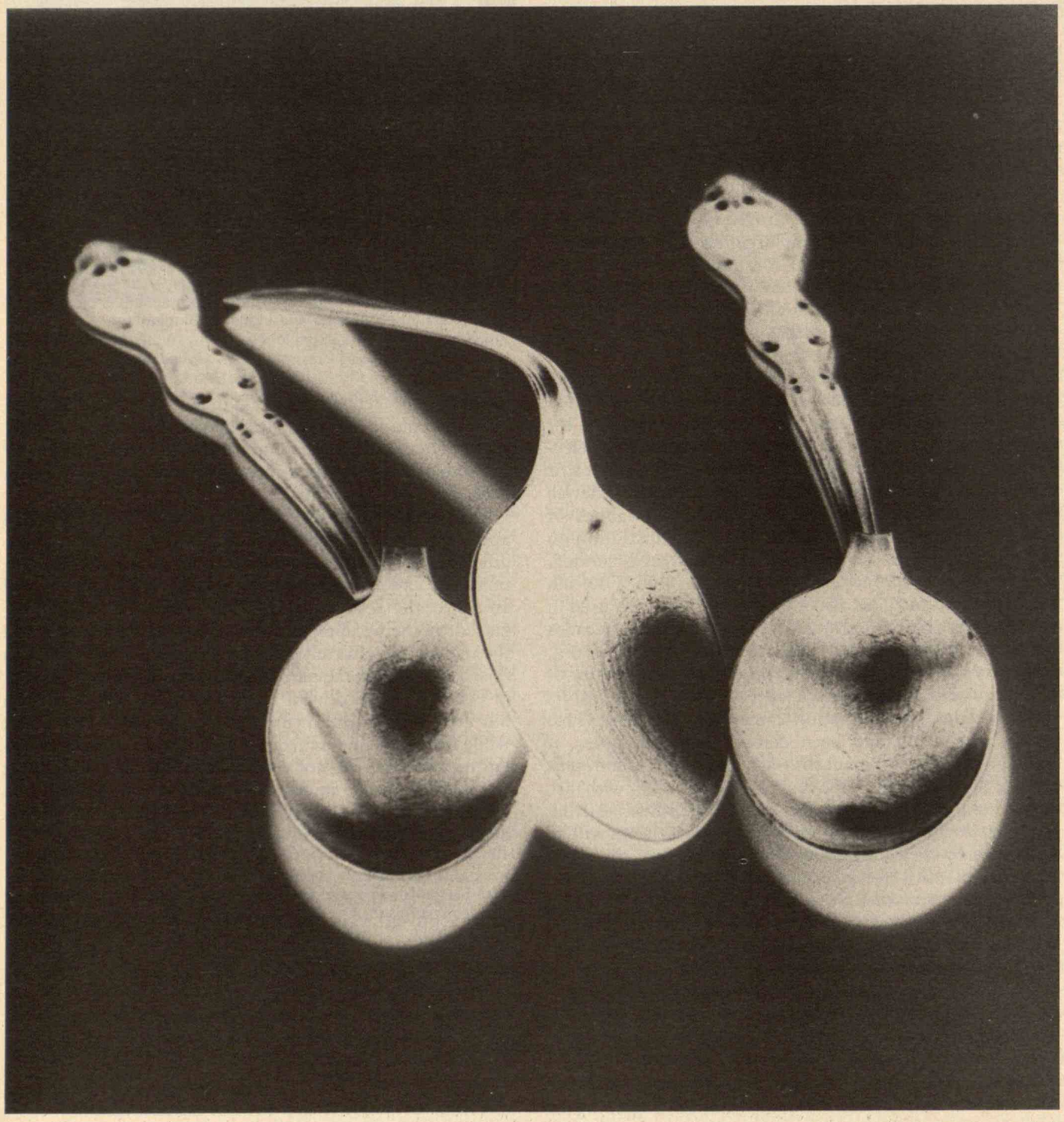
The simple picture of origins outlined above, which applies so well to the early stages of many early technologies, seems hardly applicable to the twentieth century. The experience of discovery in the laboratory is still an essentially aesthetic one (a fact rather thoroughly disguised by the accepted style of reporting the results) but the motivation is rarely a desire to create beauty. Why is this? Is it just that the patronage for creation has changed, or is it that most of what we notice today is not creation but merely a natural or unnatural refinement of the old, while the really new is around unnoticed, awaiting an environment that does not yet exist? In any case, neither art nor history can be understood without paying attention to the role of technology; and technology cannot be understood without history and art.

Cyril Stanley Smith began his career as an industrial metallurgist. He founded and was the first director of the Institute for the Study of Metals in Chicago. In 1961, he was named Institute Professor, Professor of the History of Technology and Science, and Professor of Metallurgy. His research at M.I.T. has included studies on the history of technology and the interaction of technology and art.

Author's Note

This paper incorporates, with permission, some of the text of a short copyrighted article in *The New York Times,* Section 2 of the issue of 25 April 1975. It is a particular pleasure to place a fuller version in this festschrift for Philip Morrison, for many conversations with him and his wife Phylis have helped to form the views expressed here.

Spoons and keys bent by psychic power — a new episode in the sad history of scientists deceived by sleight of hand



Photographs by Michael Feirtag

Martin Gardner

Magic and Paraphysics

The purpose of conjuring, at least most of the time, is to entertain audiences by pretending to violate natural laws. In a curious way this has something in common with how the universe behaves. When a person is mystified by a good magic trick it is because he can't figure out how the magician did it. When a physicist is mystified by an unexpected observation it is because he can't figure out how the universe did it.

The big difference, of course, is that the universe plays fair. Its tricks may operate by principles of incredible subtlety, and we may never discover all of them, but it keeps performing its illusions over and over again, always by the same methods. Or so it seems. If a scientist tries to discover one of the methods, the universe, so far as anyone can tell, doesn't go out of its way to flimflam him.

The magician, by contrast, is a consummate liar. His principles, borrowed in part from physics and psychology (but mostly they are *sui generis*), are soaked through and through with deliberate falsification of the most reprehensible sort. It is not so much what a magician says as what he implies. He will show the Queen of Hearts, turn it face down on top of the deck, and apparently deal it to the table. He may even say, "And we'll place the queen over here," knowing full well that the card he is putting there is no longer the queen. But most of the time it is what the magician does, not what he says, that is deceptive. He may tap an object to prove it solid when only the spot he taps is solid. He may casually show the palm of his hand to prove he has nothing concealed when something is on the back of his hand.

Unqualified to Detect Fraud

Any magician will tell you that scientists are the easiest persons in the world to fool. It is not hard to understand why. In their laboratories the equipment is just what it seems. There are no hidden mirrors or secret compartments or concealed magnets. If an assistant puts chemical *A* in a beaker he doesn't (usually) surreptitiously switch it for chemical *B*. The thinking of a scientist is rational, based on a lifetime of experience with a rational world. But the methods of magic are irrational and totally outside a scientist's experience.

The general public has never understood this. Most people assume that if a man has a brilliant mind he is qualified to detect fraud. This is untrue. Unless he has been thoroughly trained in the underground art of magic, and knows its peculiar principles, he is easier to deceive than a child.

Some physicists also have not understood this. In the late nineteenth and early twentieth centuries, a number of prominent scientists (Oliver Lodge, William Crookes, John Rayleigh, Charles Richet, J. J. Thomson, Alfred R. Wallace, and others) were firmly persuaded that mediums, aided by discarnate "controls," could levitate tables, materialize objects, and call up audible and even photographable spirits from the vasty deep. An Austrian astrophysicist, Johann Zöllner, wrote a book called *Transcendental Physics* about an American medium, Henry Slade, who specialized in producing insipid chalked messages from the dead on slates, and knots in closed loops of cord.[1] Zöllner believed that Slade could move the cord in and out of four-space. It was as impossible for anyone to convince Zöllner that so charming a man as Slade could be a magician as it was impossible for Houdini to persuade Conan Doyle that he (Houdini) did not perform his escapes by dematerializing his body.

And now the wretched story is happening all over again, with Uri Geller in the center of a cyclone of irrationalism that is churning over the Western world. Geller is a young, personable Israeli who began his spectacular career by performing what magicians call a "mental act" in Israeli night spots. An American parapsychologist, Andrija Puharich, discovered him, introduced him to Edgar Mitchell, the astronaut who once walked the moon and who now runs his own organization devoted to investigating the paranormal. Mitchell financed Geller's trip to the United States and arranged for him to be tested at the Stanford Research Institute by Harold Puthoff and Russell Targ, two former laser physicists now engaged in full-time psychic research. After a series of poorly designed experiments with Geller, Puthoff and Targ published their favorable findings in *Nature*.[2]

Although Puthoff and Targ are personally convinced of Geller's ability to bend metal by PK (psychokinesis) and to perform even more remarkable miracles, their *Nature* report was limited to Geller's power of ESP (extrasensory perception). His most sensational feat was guessing correctly, eight times in a row, the number on a die that had been shaken in a metal file box by "one of the experimenters." It later turned out that Geller had been allowed to handle the box, and that many prior trial runs had been made. Because the experimenters always shook the box before Geller was permitted to touch it, Geller's handling seemed irrelevant, so it was not mentioned in the *Nature* report. This seemingly trivial detail gave Geller a splendid chance to obtain information by a technique known to conjurors.[3] Had Puthoff and Targ been aware of this technique it would have been easy to take

steps to preclude it. The fact that they did not makes the dice experiment worthless.

Superminds and the Shyness Effect

Puthoff and Targ are prominent among a small group of well trained physicists, some with doctorates, who like to call themselves "paraphysicists." Most of them are active in psychic research and in publishing popular books and articles. All are convinced that psi phenomena have been firmly demonstrated by parapsychologists. That the overwhelming majority of psychologists deny this is dismissed as the stubborn prejudice of Establishment science against what Thomas Kuhn calls a new "paradigm." Paraphysicists look upon themselves as in the vanguard of a new scientific revolution that will be more shattering of old paradigms than the Copernican revolution. After all, they say, did not the establishment persecute Galileo?

In England the best known of this new breed of physicist is John Taylor, a mathematical physicist at King's College, London. When the *New Scientist* conducted a poll of its readers in 1975 they found that Taylor was regarded as among the world's top 20 scientists! The reasons for this esteem are Taylor's frequent appearances on BBC television, his popular books (including one on black holes), and his loud espousal of the "Geller effect." His latest book, *Superminds,* not only argues that Geller can bend spoons, keys, and metal bars by the power of his mind, but that hundreds of British superkids, teen age and younger, can do the same thing.[4]

Oddly, Taylor never actually *sees* anything bend, nor has he been able to capture the actual bending on video. He calls this the "shyness effect." Bending usually occurs only when nobody is looking. He has given his children crudely sealed tubes with a straight metal bar inside. They take the tubes home and come back with the bar bent. For some reason, which Taylor is unable to fathom, the children are successful only when the tubes are inadequately sealed.

At Bath University, two psychologists designed a simple test for six young spoonbenders. The observer was told to relax his vigilance after 20 minutes. Rods and spoons Gellerized all over the place while the unsuspecting children were being secretly videotaped through one-way mirrors. In every case where something bent, the children were seen doing the bending by "palpably normal means." One little girl had to put a rod under her feet to bend it. Others held a spoon below a table and used two hands.[5] Taylor had not thought it worthwhile to design such a test because he had already decided that all his children were honest.

Taylor is not sure what the mysterious force is that produces the Geller effect. In *Superminds* he considers many possibilities — gravity, the weak force, neutrinos, tachyons, intermediate bosons, magnetic monopoles, quarks. Some of these have been proposed by other paraphysicists as the source of psi phenomena. Taylor finally opts for electromagnetism. This is scoffed at by parapsychologists because, following J. B. Rhine, they believe the psi force to be unknown to science. The possibility that the Geller effect may be caused by deception is, of course, ruled out by Taylor on the grounds that he personally witnessed it.

No Search for a Beta Source

A notion of how gullible physicists can be if they have a strong compulsion to believe in paranormal events can be gained by considering a dramatic occasion at Birbeck College, London, on June 21, 1974. Uri Geller was demonstrating his powers for a small group of physicists. The most distinguished man present was David Bohm, a world-renowned expert on quantum mechanics. Also present were paraphysicists John Hasted, Keith Birkinshaw, Ted Bastin, and Jack Sarfatt (who has since changed his named to Sarfatti), and psychic researcher Brendan O'Regan, who had arranged the demonstration.

Geller's outstanding achievement was producing a "very strong burst from a Geiger counter tube that he held in his hand. The creation of the burst happened almost simultaneously with Geller's expressed intention to create it. . . . The creation of the burst was correlated with strong breathing and signs of great physical exertion on Geller's part." I quote from a stirring press release sent out by Sarfatti.[6] Geller repeated the Geiger counter bit on the following day for the writer Arthur Koestler and others. "Koestler reported a strong sensation simultaneous with the Geiger tube burst," says Sarfatti, and was "visibly shaken for several minutes." Science fiction writer Arthur C. Clarke, also there, said it was time for the magicians to "put up or shut up."

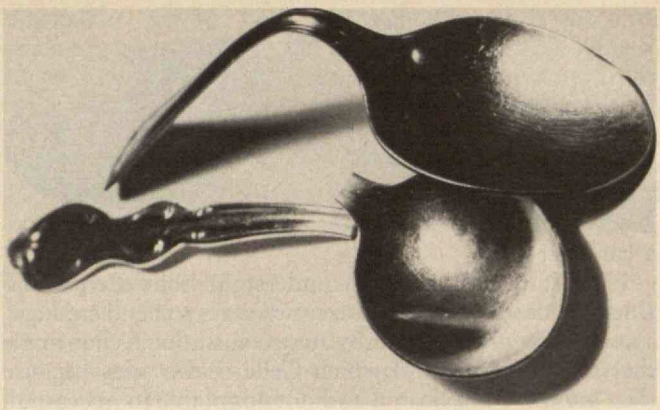
"My personal professional judgment as a Ph.D. physicist," Sarfatti concludes, "is that Geller demonstrated genuine psychoenergetic ability at Birbeck, which is beyond the doubt of any reasonable man, under relatively well controlled and repeatable experimental conditions."[7]

Note the clear implication in Sarfatti's release that having his doctorate in physics made him specially qualified to rule out deception. Well, how would a magician with no Ph.D., but with a knowledge not possessed by Sarfatti, have reacted had he been present? Although I am not much of a performer, magic has been my principal hobby for fifty years. When I read Sarfatti's account, the first thing that occurred to me was that Geller could have had a piece of harmless radioactive substance concealed on his person. While twisting about in simulated physical stress he could have simply brought the tube close to his beta source. It could have been in the tip of a shoe, above his knee, in his mouth, behind an ear, under a collar, taped to his chest, in back of his belt. It is not hard to obtain a beta source. A luminous watch dial produces excellent crackling in a Geiger counter. When Philip Morrison once asked Sarfatti if anyone had examined Geller for a beta source, Sarfatti replied that no one had thought of such a possibility, and that it was an "ingenious idea." Magicians find this response hilarious.

Was it a "repeatable" experiment as Sarfatti's release states? Perhaps repeatable in front of Ph.D. paraphysicists, but not in front of knowledgeable magicians.[8] Indeed, Geller's methods are both old-fashioned and well known. The interested reader can learn most of them by reading the references cited in notes 2 and 3.

Heads I Win, Tails You Lose

The publication of Geller's methods has had, so far, little effect on the mind sets of paraphysicists. Their reaction is exactly the same as the reaction of their counterparts around 1900 when confronted with obvious fraud by a physical medium. First, they say, the fact that a magician can duplicate a psychic event does not mean the psychic does it that way. Second, even if he *does* sometimes do it that way it doesn't mean he does it that way *all the time.* Every paraphysicist now concedes that Geller occasion-



ally cheats. After all, is not the poor lad under terrible pressure to produce results, especially on television? How can you blame him for using a little prestidigitation when the psi power is not available? If Geller is caught cheating, as he has been many times, so what? *Then* he cheated. But when nobody catches him, what he does is genuine. This is one of those old heads-I-win-tails-you-lose arguments which paraphysicists seem to find satisfying.

At the moment, Sarfatti is director of what he calls the Physics/Consciousness Research Group, a tax-exempt, non-profit organization in San Francisco. The group is funded by Werner Erhard, a former Scientologist (the church expelled him in 1971), now running a movement of his own called EST (Erhard Seminars Training), designed to raise the consciousness of anyone willing to pay for its bizarre processing.[9]

Sarfatti is the chief theoretician among U.S. paraphysicists. According to his autobiography, written in 1975 for Ken Kesey's new magazine, *Spit in the Ocean,* he was born in Brooklyn in 1939, and obtained his doctorate at San Diego State College. About ten years ago he began to have "odd subliminal experiences" which he attributes to "communication with other modes of consciousness." He found he could practice "automatic writing" (writing without conscious control of the hand) and several of his published scientific papers, he says, were written that way.

He discovered he had "a kind of collective mind experience" with his associate and "comrade in psychic exploration," physicist Fred Wolf. As his consciousness continued to soar, he was greatly aided by the EST processing. In a 1975 letter to the magician James Randi, he says that he has "serious information indicating a high probability that extraterrestrial contacts are being made." This information comes "from sober and scientifically trained people with no axe to grind," such as J. Allen Hynek, the astronomer who is now so active in UFO research. Sarfatti and Wolf are co-authors with Bob Toben of a wild paperback, *Space-Time and Beyond* (Dutton, 1975). The text plus the cartoons will tell you all about the theoretical underpinnings of such things as time travel, levitation, precognition, and the ability to bend a spoon.

Sarfatti's theory of psi stems from David Bohm's attempt to escape from the terrible discontinuities of quantum mechanics. In quantum theory one event seems to influence another without any transmission of energy through space or time. These bedrock discontinuities are utterly unlike those that occur on the macroscopic level. Rotate a beam of light and a spot will move across a wall, over an edge, then leap quickly to a more distant wall. But this leap is easily explained by considering the beam's source. Discontinuities on the quantum level cannot be explained this way. An event happens at point *A*, another event at point *B*, but nothing propagates in between. We can do no better than "explain" the event by invoking statistical laws. Conventional quantum theory leaves no room for "hidden variables" — something else about nature, as yet unknown to us, that would restore causality.

Einstein did not like this vision of "God playing dice" (as he called it) and Bohm, although he posits no deity, is equally disturbed. In Bohm's vision the universe has infinite levels of structure, like a vast sea without a bottom. On each level there are discontinuities that vanish when we perceive the patterns on the next level below. Beneath the entities of quantum mechanics are sub-quantum entities we do not yet understand. The entities we know are like tips of icebergs. We relate them by statistical laws only because we do not yet see how they are causally related on a deeper level. When we finally comprehend the deeper level it, too, will have its discontinuities, magic violations of cause and effect, that can be explained only by going still deeper. For all we know, these levels may go on forever. Our poor quantum mechanics is no more than an upper layer of what Milton called the world's "dark unbottom'd infinite Abyss."

Sarfatti elaborates. If we could but see the universe in what Bohm has called its "unbroken wholeness" we might see that every particle is connected with every other particle, every event with every other event, no matter how far away in space or time. Shake your finger, you shake the universe. Wiggle something here, everything wiggles. Where Sarfatti departs from Bohm is in the language he chooses for describing the sub-quantum level. Bohm, a materialist, doesn't call it anything. Sarfatti calls it "consciousness." He is thus in the classic tradition of philosophical idealism. Behind the crazy, paradoxical world of everyday experience, behind the even crazier world of microphysics, is Mind.

Instant Superluminal Transfer

Into this ancient vision Sarfatti stirs several modern ingredients: the "Einstein-Rosen-Podolsky" paradox, John Wheeler's wormholes and superspace, Hugh Everett's "many worlds" interpretation of quantum mechanics, and especially the implications of an argument advanced by John S. Bell.[10] Bell has shown that no *local* hidden variable theory (that is, a set of equations to describe the properties at a point in space and time) is consistent with quantum mechanics. This leaves open, however, the possibility that a non-local hidden variable theory — one that applies to the entire universe — may be consistent with quantum mechanics. There is not the slightest evidence for such a theory, but the logical possibility of such a theory — one in which God does *not* play dice — allows Sarfatti and others to posit it.

Think of the world as an immense, intricate puppet show. Everything has a "string" attached to it, and the strings are all held by the Great Puppeteer. It looks as though puppet *A* throws a particle to puppet *B*, but this is an illusion. The Puppeteer moves *A*'s arm, then carries the particle over to *B* and moves *B*'s arm to catch it. No matter how random and acausal events seem on the microlevel, causality is restored by positing the Great Puppeteer. Jung called it "synchronicity." Leibniz called it "pre-established harmony." Whatever you call the Puppeteer — God, Being, the Tao, the Absolute — its infinite

strings provide a connectedness that permits the transfer of information at instantaneous speeds through space and time.

Such a transfer must not be thought of as violating relativity's dictum that signals cannot go faster than light. There are no instant signals in the sense that energy is transferred. Nothing "moves." No time "elapses." It is what Sarfatti calls "instant superluminal transfer" of information by means of "hyperdynamical connection." In our metaphor, a puppet tugs a string here, the Great Puppeteer instantly tugs a string there.

The concept is simple, but the paraphysicist makes it sound scientific by hoking it up with technical jargon. The "measure of information," according to Sarfatti, is "the degree of order in the energy already existing at a particular place. This kind of information is coded directly to the superluminal de Broglie quantum matter waves." It is Sarfatti's persuasion that the human mind has natural detectors of de Broglie waves on the quantum molecular level. "The introduction of this kind of direct quantum information into waking consciousness often appears as 'paranormal' or 'psychic.' Certain kinds of altered states of consciousness . . . seem to facilitate awareness of direct quantum information. . . ."[11]

There is more. Not only can the psychic pick up information instantly from any part of the universe, he can also transmit it instantly. He simply uses his PK powers to wiggle a wave function here — possibly by altering the spin-state of a quantum system — and presumably wiggling it with some kind of code. Since this wiggles everything, the receiving psychic can pick it up instantly. If an establishment physicist doesn't buy this, Sarfatti and his friends consider him hopelessly mired in "electromagnetic chauvinism." (Poor John Taylor. Even though a brother paraphysicist he, too, is mired in electromagnetic chauvinism.)

Here, at long last, is a truly marvelous theory for explaining all the mind-blowing, spoon-bending wonders of psi. Information can be conveyed instantly into the skull of anyone, especially if he is psychic, from any part of the universe, from anywhere in the past, present or future. Telepathy, clairvoyance, psychokinesis, poltergeists, precognition, psychic healing, out-of-body experiences, and so on, no longer suffer from the lack of a physical theory. Our consciousness, according to Sarfatti and others, can instantly perceive and influence any part of the universe. It can leave the body and roam, faster than a photon, through endless reaches of space and time. If a superintelligence in some distant galaxy wishes to communicate with Uri Geller and give him the power to bend a spoon, there is no reason why it can't. Indeed, this is just what Puharich claims is the source of Geller's power.[12] Geller himself has validated this in TV talk shows and in an autobiography ghosted by the journalist John G. Fuller.[13]

How to Bend a Key

This is not the place to go into more details about Sarfatti's great theory of "superluminal information transfer." I wish to consider a much humbler matter. Before the paraphysicist develops elaborate theories to explain how Geller can bend a spoon, would it not be wise to make sure first that Geller actually *can* bend a spoon? By PK, that is. Now I do not wish to get into trouble with magician friends by exposing methods used by honest charlatans, but perhaps they will forgive me if I consider in detail Uri's most publicized feat. How does Geller bend

a car key?

First, it is important to understand that there is no single method. There are dozens of ways to bend car keys, some of them developed by magicians after Geller made the trick popular, and which Geller never uses because they are too complicated and not adaptable to his casual, impromptu brand of magic. But Geller himself has many ways of bending keys, depending on the circumstances. If he is performing for one person, say a reporter or a Gellerite who has asked for a private demonstration, he will do it one way. If he is in front of a large audience he adopts other procedures. The method he uses depends on who is watching, how many are watching, and how closely they are watching. If he suspects a magician is watching, he won't bend the key at all.

Here is a typical scenario based on the observation of many friends, some of them magicians whom Geller did not know were present and who actually saw his exact "moves." Let's assume Geller is in an office with a group of scientists gathered to witness his awesome powers. Some of them believe Geller has those powers. Others are skeptical but curious. None knows much about magic.

In performing for such an audience Geller has one overwhelming psychological advantage over every magician: he comes on as a psychic. A magician is expected to perform his miracles rapidly and cleanly, without fail, while everyone watches like a hawk to see if they can catch the trickery. No magician, when he gets up to perform, dares say, "I'm sorry, ladies and gentlemen. I intended to show you my great trick of floating a burning light bulb across the room, but unfortunately I don't feel like doing it. There are sceptics in the audience. The vibes are unfavorable."

The psychic, on the other hand, is under no obligation to do anything, and Geller plays this role with superb skill. He begins by saying that he is very nervous, being in such distinguished company, and he doesn't know whether anything will happen or not. All he can do is try. Things are more likely to happen, he says, if everyone wants them to happen. The power he has is not peculiar to himself. Everybody has it. So — if everyone will try their best to make things happen, maybe they will. But don't be disappointed if they don't.

This little speech has the effect of discouraging sceptics from voicing doubts. It also gets Geller off the hook if he finds that conditions do not permit him to do much. Most of all it allows him plenty of time to perform the most trivial of tricks. No magician could possibly get away with taking half an hour to make a key bend, but this often happens with Geller. He will borrow a car key, stroke it, nothing happens. He will put it aside and try later. Again nothing happens. Perhaps on the third or fourth try it will bend.

The reason for this delay is that Geller cannot bend the key until he obtains strong enough misdirection to bend it secretly. The secret bending takes only an instant. Most car keys bend easily, especially if they are long and have a low-cut notch. Geller prides himself on his strength (he

works out with bar bells, Puharich tells us). If you have strong fingers you can bend most car keys simply by resting the key crosswise on the fingers and pressing firmly with the thumb. Stronger keys require pressing the tip against the side of a table, the table leg, the side of a chair, or whatever firm surface is handiest. In any case, the bending can be done in a split second. Of course it must be done at a moment when no one is looking.

The Key-Bender's Art

To obtain the necessary misdirection Geller creates a maximum amount of chaos by moving around the room and going quickly from one experiment to another. Here are some of the ploys he has used to get the needed misdirection.

1. Geller has tried twice to bend a key but without success. He tries a third time, letting someone hold the base of the key while he gently strokes it with a finger. Again nothing happens. Geller acts disappointed. Everyone is disappointed. He starts to put the key aside once more. No one is paying much attention because the trick has failed. At that instant someone in the room makes a funny remark. Everyone turns toward him and laughs. It is the moment Geller has been waiting for. His hand drops to the side of the chair while he himself is laughing. Who except a trained magician would be watching his hand at that instant? Geller immediately puts the key aside, carefully placing it in a spot where it is partly concealed so that no one can see the bend. He may not try the key again for another ten minutes.

2. Geller is performing for one person. Both are seated in chairs. The key fails to bend. Perhaps, Geller says, they are sitting too far apart. To move his chair closer, Geller's hands drop to the sides of the chair. As he moves the chair, the tip of the key is pressed against the chair's leg.

3. Geller is in his own apartment entertaining a guest. He sits on a sofa behind his glass-topped coffee table. There seems to be nothing near him he can use for a pressure bend. Who would guess that the thick glass of the coffee table will serve admirably? As soon as a bit of misdirection occurs, and the spectator's attention is diverted, the key is bent against the edge of the glass.

4. Geller is entertaining a group of people in an office. They are watching too closely for him to obtain the misdirection he needs. Geller is apologetic. Sometimes it helps the metal bend, he says, if there is a lot of metal nearby. He points across the room and asks, "Is that a metal file cabinet?" If he is in a living room he points to a radiator. Every head turns. In that instant his hand lowers and puts in the work. If the key is weak he bends it in his hand. All he has to do now is hold the key at one end, concealing the bend, walk to the file cabinet, let someone hold an end of the key, then miraculously bend it.

5. On many occasions Geller finds it necessary to leave the room to obtain strong misdirection. In 1974 when he was performing for a group of people in Ottawa, a friend of mine in the audience told me that, after many failures to bend a key, Geller asked if there was an elevator in the hallway. The large amounts of metal in the shaft, he said, might help. Geller then dashed into the hallway, his spectators trailing. Sure enough, in front of the elevator door the key bent.

6. Another one of Geller's favorite excuses for leaving the room is to say that running water helps a key bend. He actually used this preposterous excuse on the paraphysicists at Birbeck College. Let me quote the relevant passage from Sarfatti's ecstatic press release:

"Geller then succeeded in bending several pieces of metal by psycho-energetic action. These objects included the blade of a knife and a key belonging to Bohm. The flow of water from a tap on to the metal seemed to make the bending occur more easily."

To a magician this means that the paraphysicists had been watching too closely. Geller suggested flowing water. Everybody moved to a spot where the key could be held under a tap. In the process of getting there, Geller obtained the needed misdirection. He could have bent the key in his hand, against the side of a doorway as he passed through, or in a dozen other ways. The point is: no one is watching on the way to the sink.

The Illusion of Bending

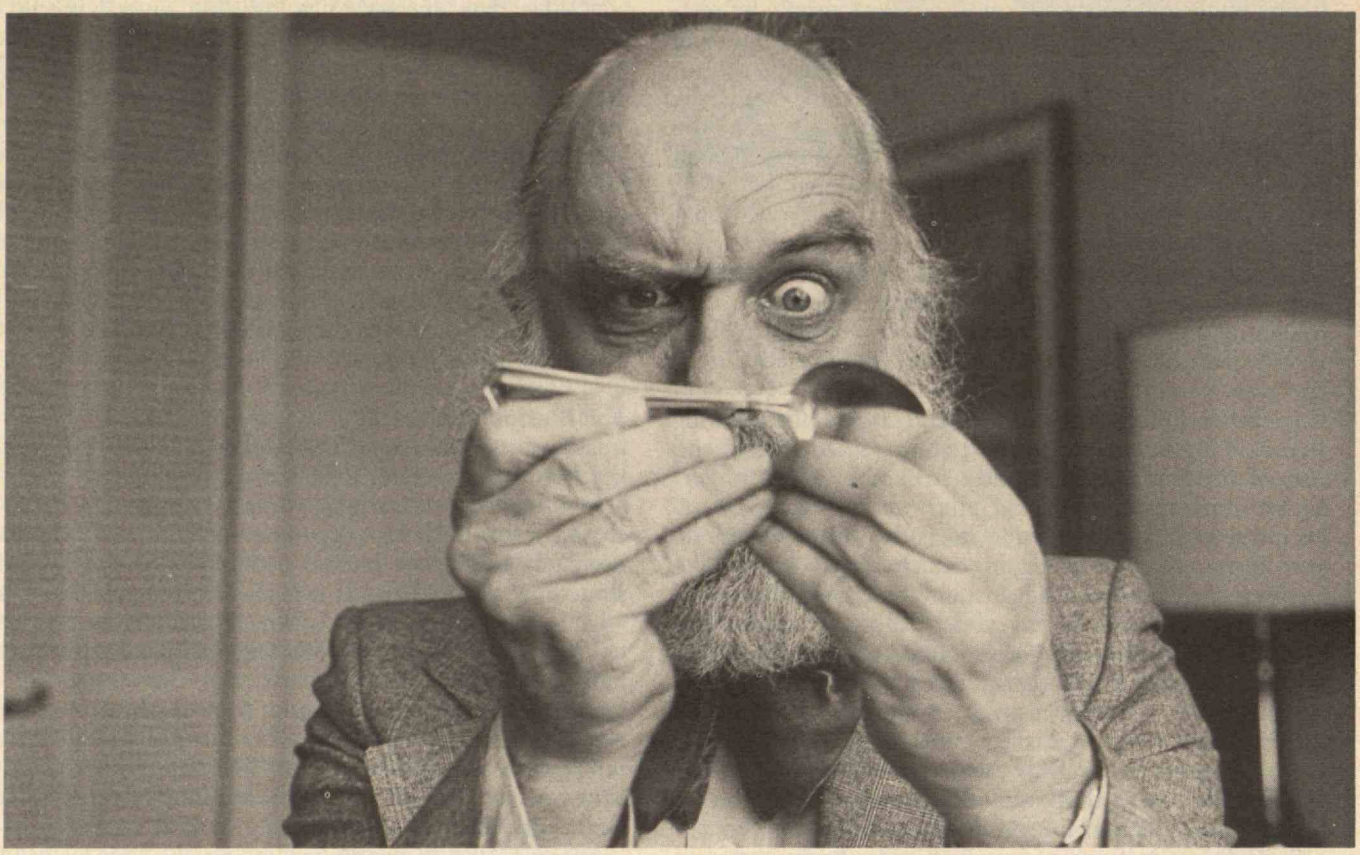
It is important to realize that Geller puts the bend in the key before, sometimes long before, he pretends that the actual bending takes place. Let's suppose he finds a chance to bend the key after a second failure. The key has been put aside, but behind something or partly under something so the bend is not visible. Ten minutes later, when he picks up the key again, he holds it so that only half the key projects from his fingers. Because the visible half is straight, everyone assumes the entire key is straight. Sometimes he rubs the bent key back and forth across a table top. The action and sound strengthen the impression that the key is flat. The key is then given to someone to hold at one end while Geller's fingers surround the bend.

While Geller is gently massaging the key he usually asks if the key is beginning to feel warmer. Since it is being handled, it *is* getting warmer, but most people respond readily to suggestion and imagine that the key is feeling much warmer. Geller continues to rub the key. Slowly he lowers his fingers and allows the bend to come into view. It really looks as if the key is bending at that moment, especially if that is what you are convinced is happening. Geller is a master at creating this illusion. He will see to it that the flat side of the key is toward the audience as he lowers his fingers. Then he will twist the key gradually to bring the bend slowly into view. At the same time he will shout excitedly, "Look! It's starting to bend!" All this combines to create a strong illusion. Many people will swear later that they saw the key slowly bend, the way a match bends while it is burning.

Sometimes Geller will hand a key, already bent after an earlier "failure," to a spectator. If no one else is present, Geller may ask him to hold the key by its tip but above his head where he can't see it is already bent. Geller will then announce that he is going to attempt something he seldom does. He is going to move across the room, ten feet away, and try to bend the key without even touching it.

The person holding the key naturally assumes it is unbent. Geller, ten feet away, tries hard to make the key bend. He walks forward, examines the bent key, and acts tremendously disappointed. Nothing has happened! Before the spectator has looked at the key — why should he examine it since the key clearly failed to bend? — Geller is anxious to try once more. The key goes back in the person's hand, the hand is raised. Geller moves twenty feet away. Now he feels the power surging through him! He breathes heavily and seems to be undergoing considerable stress. Yes — he *knows* the key is bending! "Do you feel it bending?" If the spectator is suggestible he im-

Continued on page 50



Faking a Psychokinetic Miracle: The Amazing Randi Shows How

The magician's greatest allies in deception are the brains of an audience, intent on discovering fraud, for the brain is always making assumptions about the world, and interpreting its sensory input so as to support its expectations. The audience may believe that the magician is watched the way a bank's camera monitors a robbery, but this isn't true. It has been known for decades, for example, that the brain has circuitry descending from its cerebral cortex that might actually censor the information arriving from receptor organs such as the eyes.

The methods by which the brain makes order out of its perceptions are unknown, but the magician knows how to capitalize on them. Under his inducement, the audience pays attention to unimportant aspects of his performance and misinterprets or never sees the important ones.

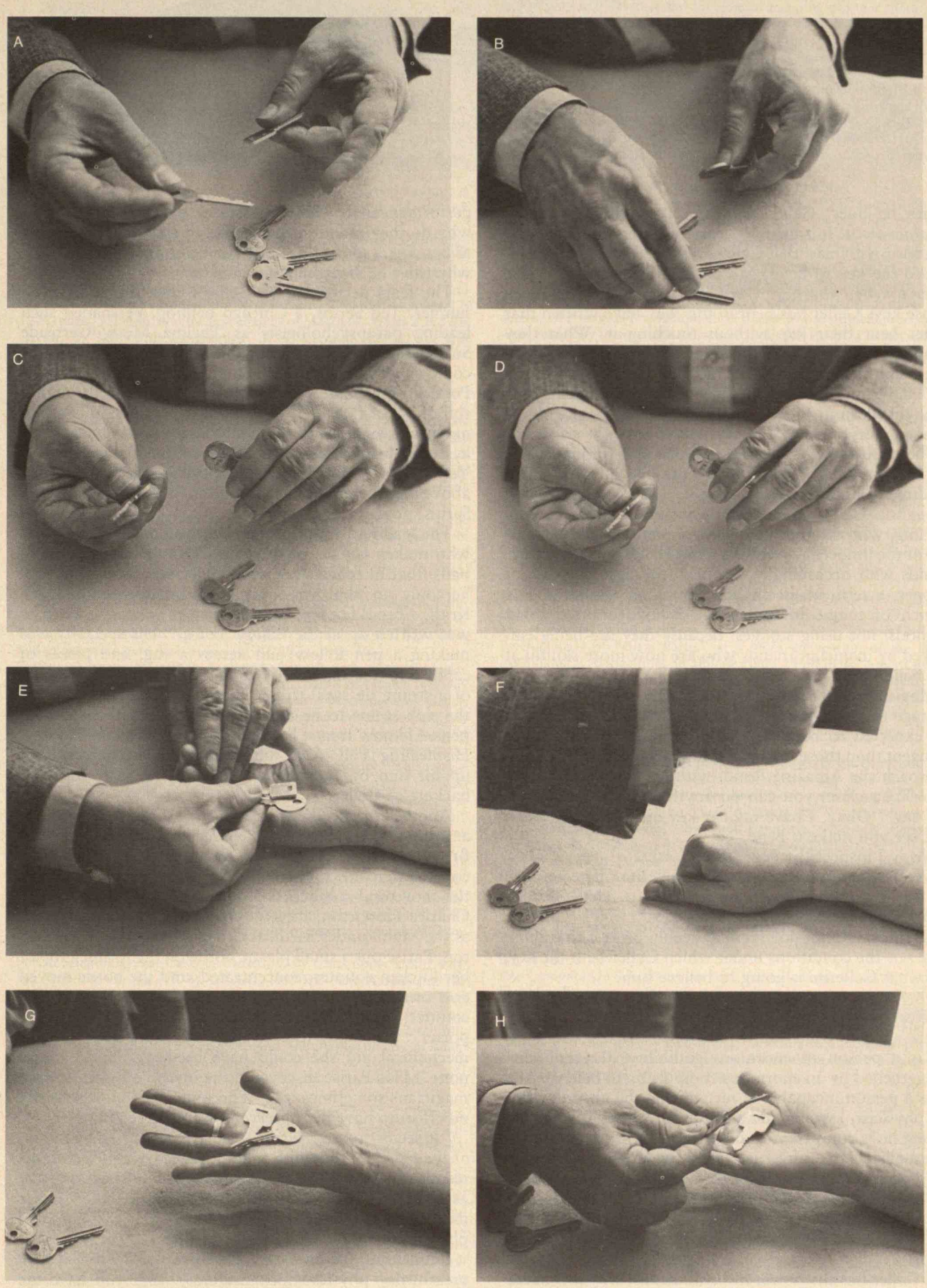
The Amazing Randi is a magician and escape artist. He has several techniques of key-bending; he learned some, he says, by studying videotapes of Uri Geller's television appearances, and has devised others. Recently he consented to have his "moves" photographed by *Technology Review*.

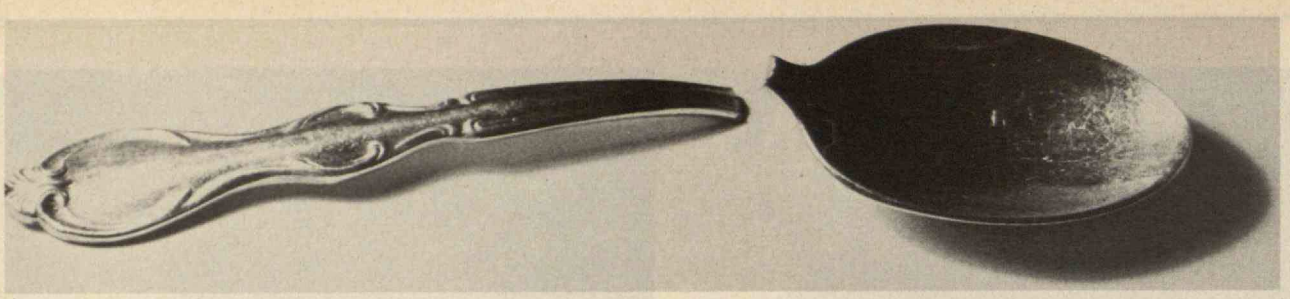
The accompanying sequence of eight photographs reveals one technique of "miraculous" key bending. Randi begins as Geller often does: by examining several keys (photo A). Observers, never knowing exactly what to expect but hoping anxiously not to miss a key bending, tend to concentrate on Randi's right hand (at the left in the photographs), which is very animated: it scrabbles eagerly among the keys (B), then chooses a key and begins to stroke it (C). Meanwhile the magician's left hand, relatively unnoticed, picks up a key with a large eyelet in its head (A), then picks up a second and surreptitiously inserts it into the eyelet of the first (B).

In photo C, Randi appears to be passively holding a key in his left hand. The manner in which he holds it does not appear conducive to applying pressure. In fact it is — the key is bending, but by muscular, not psychic, effort. In photo D, Randi's spread fingers reveal that he is using the hole in the first key for leverage in bending the second at a point where it is deeply notched.

Now Randi transfers the two keys in his left hand to the subject's hand (E). The bend remains hidden. Nothing the subject — or an audience — has seen thus far will suggest that the key is already bent. In fact, the unbent portion that *is* visible is subliminally reassuring. The brain makes all manner of extrapolations from the seen to the unseen portions of objects: this is the basis of many optical illusions.

In photo F, the subject's hand is closed and Randi, making a fist above it, wills the key to bend. "Do you feel anything?" he asks anxiously. A suggestible person does, and anyone might: the keys lie clenched over a throbbing blood vessel in the palm. It remains only to have the observer open her hand and reveal the miracle (G). When Randi picks up the key (H) the bend may appear to have increased — merely a matter of viewing angle. — *M.F.*


A
B
C
D
E
F
G
H



agines he does. Geller tells him to look at the key. *Mirabile dictu*! It is bent 30 degrees! To his dying day the spectator will insist that Geller was 20 feet away when he caused the key to bend. Moreover, he will insist, Geller *never touched the key*. Over and over again, reporters whose keys Geller has bent in this way have written that Geller bent their key without touching it. What they mean is that Geller was not touching it at the time they assumed it was bending. The fact that Geller handled the key many times before the great miracle occurred seems totally irrelevant. Indeed, the fact may slip totally out of their memory.

These are a few of the dodges Geller uses for just one of his little miracles. I have not mentioned all of his key-bending techniques. For example, I have said nothing about how Geller can be secretly aided by his friend, Shipi Shtrang, who is often with him, sometimes disguised as one of the innocent spectators. And Geller has other close friends who occasionally "stooge" for him. The use of stooges, a term magicians use for secret assistants, is a branch of magic in itself. And I have omitted other methods, not using stooges, because they are being employed by magician friends who are now more skillful at key bending than Geller.

Magicians are, of course, under the enormous disadvantage of being known as magicians. As a result, they are expected to bend a key under conditions far more stringent than those demanded for Geller. A Gellerite will approach the Amazing Randi with his fist closed over a key. "You claim you can do anything Geller does," he will say. "Okay, I have my car key inside my fist. Now let's see you make it bend."

"May I inspect the key?" Randi asks.

"You may *not*," says the angry Gellerite. "The key is in my fist. Make it bend without touching it. That's exactly what Geller did when he bent my key."

What can Randi do? He may feebly protest that those were *not* the conditions under which Geller bent the key, but what Gellerite is going to believe him?

As Real as the Eskimos

There are two traits that characterize the true Gellerite. He is a person of enormous gullibility, the gullibility strengthened by an enormous compulsion to believe. And he is a person incapable of recognizing the absurd. (If he is a physicist, I would add a third trait: the egotism of believing he is competent to detect fraud.) In the heyday of spiritualism, the physicists who were convinced that spirits could float trumpets through the air were not in the least amused by the singular fact that spirits could do this only in total darkness. Why should the dear departed operate only in the dark? To a magician the answer is obvious.

If Geller has the power to bend metals, why is it necessary to bend them only under the conditions of a magic performance? If Geller possesses paranormal powers, why do they manifest themselves in such picayune ways as bending a spoon? If Geller can bend a metal bar by PK, why can't he straighten it again?

The feats performed by Geller's chief rivals are even funnier. Ted Serios, a Chicago bellhop, persuaded such leading parapsychologists as Thelma Moss, Gertrude Schmeidler, William Cox, and Jule Eisenbud that he could cause his memory of old photographs to register on Polaroid film merely by looking into the lens through a roll of paper that he held in front of the lens. When two magicians explained how easily Serios could have faked it, Serios lost his power and faded from the psi scene.[14] Yet not one of the four parapsychologists mentioned above has altered his or her opinion of the genuineness of Serios' power.

The leading PK performer in Russia is Nina Kulagina, who makes objects move across a table and ping-pong balls float in space. American magicians, who have seen her only on film, are enormously unimpressed.[15] Dean Kraft, a Brooklyn boy, made a stir two years ago when he was written up in the *Village Voice*.[16] His specialty was making a pen follow him across a rug, and pieces of candy hop out of a bowl. He soon gave this up (too much of a strain, he says) to become a psychic healer. Curing the sick seems to be much easier for him than moving pens. He now treats, he claims, about 30 patients a day. His healing is all "free," but patients donate to a fund set up for him by Judy Skutch, one of the early financial backers of Geller.

Another recent PK wonder in the U.S. is Felicia Parise, a former medical assistant at Maimonides Hospital in Brooklyn. After seeing a film about Kulagina, Parise discovered that she, too, could make corks, tinfoil, and bottles move and roll across a table. She was discovered by Charles Honorton, director of parapsychology research at the Maimonides Medical Center. According to Honorton, Parise put a small plastic bottle on the formica top of her kitchen counter, concentrated, and the bottle moved two inches away from her. "I then examined the counter," this distinguished parapsychologist told a reporter. "I virtually took it apart to ensure there was no mechanical aid she could have used. . . . But I found none." Has Parise discovered the invisible nylon threads magicians sometimes use? Who knows? Honorton made no effort to have her observed by a qualified magician.[17]

"It seems to me," wrote Conan Doyle in *The Coming of the Fairies,* "that with fuller knowledge and with fresh means of vision, these people are destined to become just as solid and real as the Eskimos." By "people" Doyle meant tiny creatures with filmy wings that two girls had photographed in the woods of Yorkshire.[18]

Substitute "psi energies" for "people," and "laws of present-day physics" for "Eskimos," and you have the heart of what the paraphysicists are trying to tell us.[19]

Footnotes

1. Zöllner's book, must reading for all Uri Geller watchers, was first published in Germany in 1879. An English translation by C. C. Massey (1880) had many British and U.S. editions. Zöllner's investigations of Slade were assisted and endorsed by physicists William E. Weber and Gustave Fechner, and mathematician W. Scheibner. Alfred Wallace and Lord Rayleigh were firmly convinced of Slade's powers. For a defense of Slade, see Conan Doyle, *History of Spiritualism* (1926). For Slade's methods, consult the 1887 report of the Seybert Commission, which caught Slade in outright fraud; J. W. Truesdell, *Bottom Facts of Spiritualism* (1883); Walter Prince, "A Survey of American Slate-Writing Mediumship," in Section 2, *Proceedings of the American Society for Psychical Research, Inc.,* Vol. 15 (1921); Harry Houdini, *A Magician Among the Spirits* (1924); and John Mulholland, *Beware Familiar Spirits* (1938).

2. "Information Transmission under Conditions of Sensory Shielding," by Russell Targ and Harold Puthoff, *Nature,* Vol. 251, October 18, 1974, pages 602-607. For mild criticism of this paper see the editorial on page 559 of the same issue. For strong criticism, see "Uri Geller and Science," by Joseph Hanlon, *The New Scientist,* Vol. 64, October 17, 1974, pages 170-186, and the first chapter of *Mediums, Mystics and the Occult,* by Milbourne Christopher, T. Y. Crowell (1975). For still stronger criticism, see *The Magic of Uri Geller,* by James Randi, Ballantine Books (1975).

3. This technique was explained by Houdini in a rare pamphlet that Randi reprints in his book. It is also explained in *Confessions of a Psychic,* an anonymous booklet published by Karl Fulves (1975) for sale to the magic trade. Interested readers can obtain a postpaid copy by sending $3.30 to Fulves, Box 433, Teaneck, N.J. 07666. The booklet pretends to be the secret diary of Geller's chief rival, a mythical Uriah Fuller, but it contains the most detailed explanations to date of Geller's methods.

4. *Superminds* was published in 1975, in England by Macmillan, in the U.S. by Viking. See also Taylor's article, "The Spoon Benders," in *Psychic,* Vol. 6, December (1975) pages 8-12, and my review of *Superminds* in *The New York Review of Books,* October 30, 1975, pages 14-15.

5. See "Spoon Bending: an Experimental Approach," by Brian R. Pamplin and Harry Collins, *Nature,* Vol. 257, September 4, 1975, page 8.

6. Sarfatti's release was reprinted in psychic journals around the world, and in *Science News,* Vol. 106, July 20, 1974, page 46.

7. Since I wrote this article, Sarfatti had lunch with magician James Randi, who fractured a spoon and moved the hands of a watch in a way that Sarfatti found indistinguishable from his observations of Geller. This prompted Sarfatti to reverse his opinion and fire off another press release (dated November 19, 1975) which begins: "On the basis of further experience in the art of conjuring I wish to publicly retract my endorsement of Uri Geller's psycho-energetic authenticity." This release appeared as a letter in *Science News,* December 6, 1975, page 355. "I do not think," Sarfatti writes, "that Geller can be of any serious interest to scientists who are currently investigating paraphysical phenomena." Sarfatti does not doubt that PK powers exist. He merely doubts now that Geller has them.

8. One must add "knowledgeable" because there are no doctorates in magic, and obviously anyone, no matter how puerile his magic background, can pose as an authority. Several self-styled experts on conjuring, considered eminently unknowledgeable by other magicians, have watched Geller perform and pronounced him genuine: notably William E. Cox, an associate of J. B. Rhine.

9. On Scientology, see *Cults of Unreason,* by Christopher Evans, Farrar, Straus & Giroux (1974). On EST, see "The New Narcissism," by Peter Marin, *Harper's Magazine,* October, 1975; "We're Gonna Tear You Down and Put You Back Together," by Mark Brewer, *Psychology Today,* August, 1975; "The Führer Over EST," by Jesse Kornbluth, *New Times,* March 19, 1976, pages 36-52; the chapter on EST in Adam Smith, *Powers of Mind,* Random House (1975); and my review of Smith's book in the *New York Review of Books,* December 11, 1975, pages 46-47.

10. See J. S. Bell, "On the Einstein Podolsky Rosen Paradox," *Physics,* Vol. 1 (1964), pages 195-200, and Nick Herbert, "Cryptographic Approach to Hidden Variables," *American Journal of Physics,* Vol. 43, April (1975), pages 315-316.

Herbert, a friend of Sarfatti, is currently director of what he calls CORE Physics Technologium, a division of C-Life Institute, Boulder Creek, California. The "institute's" purpose is "to design, develop, and eventually produce material products in which consciousness is a significant component." The institute's list of 26 "areas of research" includes alien entity communication machines; astral travel vehicles; conscious control of chemical reactions; ideospecific love charms for attracting, binding, and holding; Maxwell-demon power generators; mechanical telepathy; PK earth-moving equipment; psychic sports, toys and recreational devices; and topological mapping of inner space. (All these terms are from an August 22, 1975, CORE release.)

11. My quotations from Sarfatti are taken from releases distributed by his Physics/Consciousness Research Group, and from his essay, "The Physical Roots of Consciousness," in *The Roots of Consciousness,* by Jeffrey Mishlove. Mishlove is a graduate student in philosophy at the University of California, Berkeley. His big, lavishly illustrated book (with color plates showing how psychic surgeons remove diseased body tissues without slicing the skin) was published by Random House in 1975. It is an incredible Mishlovemash of every crazy aspect of the current psi scene.

12. See *Uri,* by Andrija Puharich, Doubleday (1974).

13. *Uri Geller: My Story,* by Uri Geller, Praeger (1975). John G. Fuller, the actual author, should not be confused with Curtis Fuller, editor of the psychic pulp magazine, *Fate*; with Willard Fuller, the psychic dentist of Jacksonville, Florida (he fills cavities without touching the teeth); or Uriah Fuller, the legendary rival of Uri Geller. John G. Fuller is the author of many books, some of them on UFOs and on the occult. His book *Arigo: Surgeon of the Rusty Knife,* T. Y. Crowell (1974), is an all-out defense of a famous Brazilian medical quack whose surgical procedures were guided by instructions whispered in his left ear by a dead German doctor.

14. See "An Amazing Weekend with the Amazing Ted Serios," by Charles Reynolds and David B. Eisendrath, Jr., *Popular Photography,* October, 1967, page 81f.

15. Parapsychologists take Nina Kulagina very seriously. She began her career as one of several Russian ladies who claimed to be able to read *Pravda* with their fingertips. (See "Dermo-Optical Perception: A Peek Down the Nose," by Martin Gardner, *Science,* Vol. 151, February 11, 1966, pages 654-657.) After a short term in prison (for black marketeering) she emerged as the Soviet Union's number one psychic. There is a good section about her in *Psychic Discoveries Behind the Iron Curtain,* by Sheila Ostrander and Lynn Schroeder, Prentice-Hall (1970). J. Gaither Pratt, a former associate of Rhine, is one of Mrs. Kulagina's strongest supporters. See *The Psychic Realm,* by Pratt and Naomi A. Hintze, Random House (1975).

16. "The Brooklyn Healer," by Brian Van der Horst, *Village Voice,* December 23, 1974; reprinted in *Cosmopolitan,* August, 1975.

17. Honorton announced his discovery in his "Report on the Psychokinesis of Felicia Parise" at a 1973 convention of the Parapsychological Association, an affiliate (since 1969) of the American Association for the Advancement of Science. His claims were backed by Graham Watkins, then working for Rhine. Watkins reported on Parise's ability to make a compass needle move, and to fog unopened film near the compass — all, of course, under "strict" laboratory controls, no magicians present.

A film documenting Parise's powers was shown at the convention by physicist Edwin May. "Physics does not have any idea how these phenomena work," May told a reporter. "Now we're trying to find out where her power comes from." See "Amazing U.S. Woman Moves Objects with Mind Power," by Paul Bannister, *National Enquirer,* December 30, 1975, page 4; and "Apparent Psychokinesis on Static Objects by a 'Gifted' Subject: A Laboratory Demonstration," by Graham K. Watkins and Anita M. Watkins, *Parapsychology Research 1973,* pages 132-134.

18. Doyle's preposterous book was reprinted in 1972 by Samuel Weiser, Inc., Manhattan's leading occult bookstore. On this book see my essay "The Irrelevance of Conan Doyle" in *Beyond Baker Street,* Bobbs Merrill (1976).

19. Compare Doyle's statement with the following remark by Wilbur Franklin, Professor of Physics at Kent State University and one of the nation's leading Gellerites. "I'm convinced there is nothing mysterious about Geller's or any other psychic's feats. Once we understand the natural laws that govern such things, we will also understand psychic phenomena as clearly as we understand such natural laws as gravity." (*The Star,* December 30, 1975, page 17.)

Martin Gardner has conducted "Mathematical Games," a monthly column in *Scientific American,* since 1957. His numerous books include *Relativity for the Million, The Ambidextrous Universe, Fads and Fallacies in the Name of Science,* annotated editions of works by Lewis Carroll, and collections of mathematical and numerological puzzles and diversions. His principal hobby is conjuring. He contributes to magic journals and has written many small books on magic that sell to the trade.

Jerome Y. Lettvin
Professor of Communications
Physiology
M.I.T.

The tales of the Makers are the first language of science

The Use of Myth

In 1890, Norman Lockyer, an English astronomer, visited Egypt, drawn by its massive monuments. He was interested in whether he could find any influence of astronomy in their construction. Thereby, he hoped to use his science in setting the chronology of ancient times.

There was good and sufficient reason for his suspicion. Our daily language embodies knowledge of the heavens that was had before writing began. The week has seven days that mark the quarters of the moon in the mo(o)nth that lies between full moons. So much does Alex Marshak show in the marked bones and stones of neolithic times. And these seven days are named after the only seven visible bodies that regularly move in the heavens as if independent of the stars. There are Sun-day, Moon-day, Diw's Day (Mars), Wodin's Day (Mercury), Thor's Day (Jupiter), Freya-Day (Venus) and Saturn-day. These visible planets are the five wanderers of antiquity.

God-names have always been associated with the sun, moon, stars and planets. We also inherit the non-overlapping partition of the sky into constellations, some of which, like the Lion and the Scorpion, have kept the same names for over four thousand years since the Sumerians first inscribed what was already ancient learning to them. Many of the constellations, such as the Big Dipper, formerly the Wain, or Wagon, have preserved their star composition but only changed names over the centuries. Important single stars, such as Sirius, have always had separate names. And most of the constellations are called after beasts, monsters, heroes and heroines, but never after gods. For the gods are stars as Plato says.

The relation of the movements of the moon and planets to the fixed constellations engendered the zodiac, which is born in prehistory, scribed in part on Sumerian boundary markers, and shown by panorama in the circular display at Denderah in Egypt.

So lawfully does the whole firmament move, so lawfully do the wanderers and the sun and the moon change with respect to the stars, that no terrestrial happenings, save for the tides, can rival the heavenly system. The order of happenings on earth takes a history, an endless chain of specifics. But the heavens take one description, for in the sky time is circular. There are to be no events in that fixed, slow harmony but only the necessary succession of views passing insensibly into each other in an eternal round. Against this background of expected certainty in the familiar sky the intrusions of comets and eclipses bring terror, for these are events, singularities that interrupt the perfection of the divine clockwork — intimations of mortality.

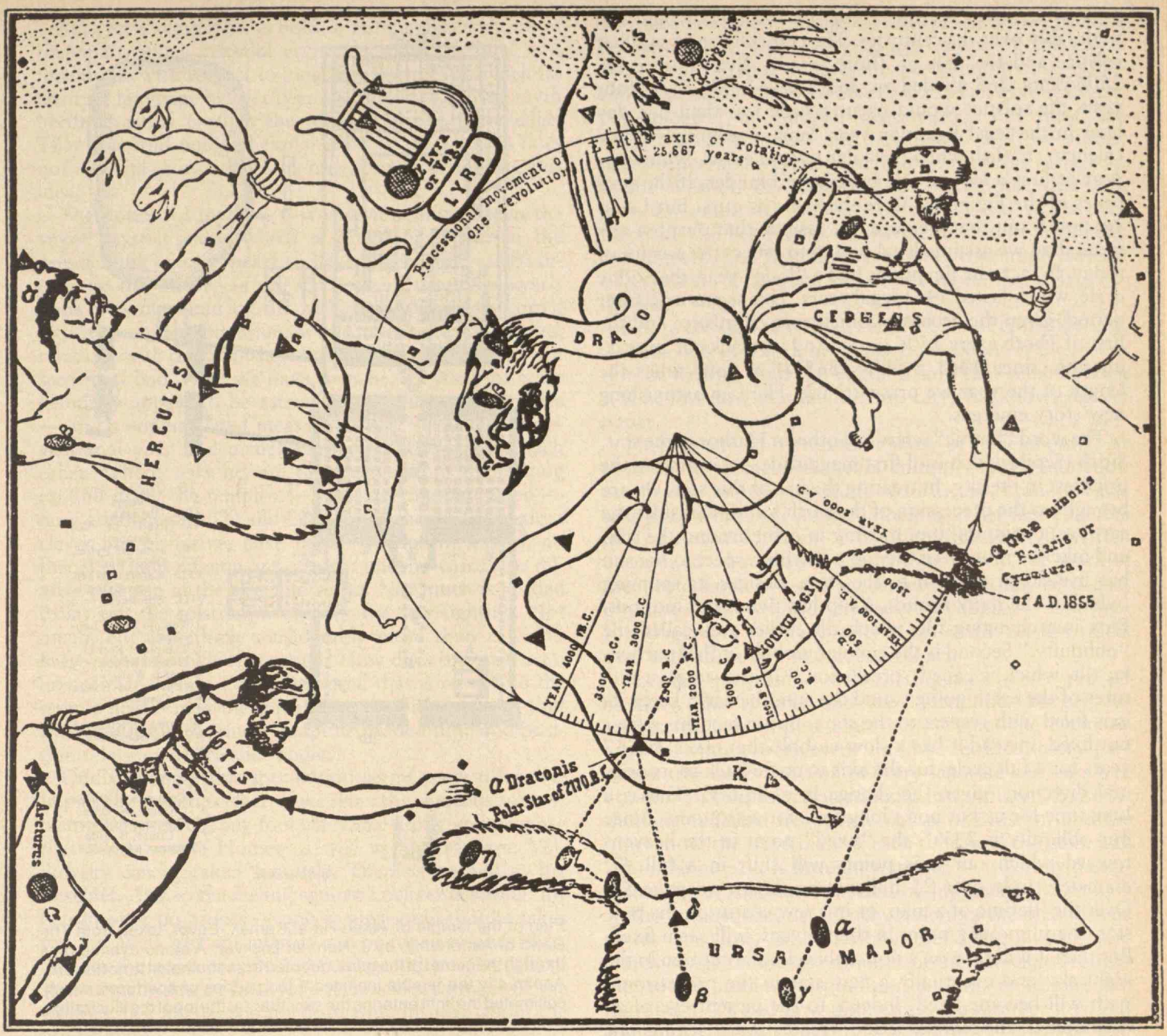
Were the heavens not a central concern of the ancients, why did comets and eclipses and novae affect them so conspicuously even unto very recent times? So much would be granted by any scholar. Then, if indeed the gods are stars and we are subject to heaven as much as to earth, is it not reasonable to expect some astronomy to be involved in the way that temples were built?

So, in effect, reasoned Lockyer, and went to Egypt. Standing in the temple of Amen-Ra at Karnak, he wondered at its plan, which is given on page 54. Leading to the sanctuary at the southeast end is a series of apertures in a marvelously straight line, an avenue to the northwest some 500 yards long, well over a quarter of a mile.

Astronomers, like other craftsmen, recognize the tools of their trade. Lockyer, noting the remarkable straightness, the uncommon length of the corridor, and the frequency of apertures, was convinced that it could only be an optical instrument, a collimator as in modern telescopes. Therefore, he considered the point at the horizon upon which this instrument was trained, for tradition had it that one day in the year the statue of the sun-god would glow in the sanctuary. This was called the "Manifestation of Ra."

There are only two days in the year for which this singular manifestation is possible. One is the winter solstice (at the Feast of Fools on December 21), the other is the summer solstice (at Midsummer on June 21). If you watch sunrise or sunset every day from your bedroom and mark where it occurs with respect to fixed distant structures on the horizon, you will see that successive risings and settings move slowly back and forth between north and south as if the sun path were on a pendulum with a swinging period of one year. The northern limit of the northward swing is the summer solstice, the southern limit of the southward swing is the winter solstice. Consider only the setting sun. Facing west, you will see the right-hand edge of the sun cross a particular point on the horizon at summer solstice. If you train a long, narrow tube on that point and fix it firmly to the ground, you will not see a ray of sun through that tube until the next summer solstice, for on all other days the right edge of the sun will be south of the point to which the tube looks. At all other points in the course of sunsets, light will show during two clusters of days, one when the sunsets pass during the northward swing, the other when they pass during the southward swing.

What excited Lockyer immensely was that on 21 June 1891 the sunset could not be sighted down the avenue from the sanctuary. The right-hand limb of the sun was



A star map showing the precessional movement of the celestial north pole from 4000 BC to 2000 AD. The pole moves through a circle over a period of 25,667 years. Accordingly the pole star of antiquity was Alpha Draconis, not Polaris.

setting 1°, or about twice the sun's diameter, too far south at the summer solstice. And this was as it should be. For, if the temple were built about 6000 years ago, the tilt of the earth's axis with respect to the plane of its orbit (the ecliptic) was then about 1° more than it is now. This slow shift of the tilt of the earth's axis to the ecliptic is not the precession of the equinoxes; that is very different and will be treated shortly. The present tilt, called the obliquity, is about 23°27′. In 5000 B.C. it was 24°22′. The change is due to the plane of our orbit being affected by the mass and orbits of the other planets.

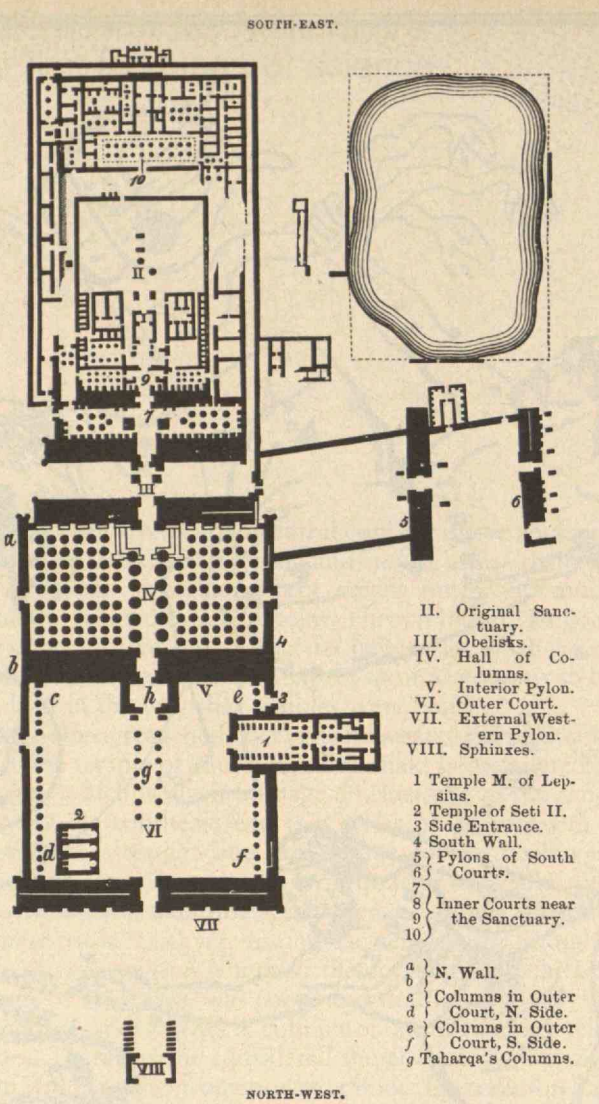
The temple of Amen-Ra at Karnak was oriented on the summer solstitial sunset and must then be as tradition had it — a marker for the year, and an accurate one. Nor do I think that with a dispassionate view of the construction as shown, the measurements of Lockyer, and the description of the "Manifestation of Ra," any other conclusion is possible.

But now a complex refinement issues that Lockyer tries to piece together. Certainly with such an instrument to set the solar year accurately, it would seem that a "proper" calendar was possible. Yet the kings of Egypt, on taking the throne, had to swear an oath not to change the length of the year from a fixed 365 days (cf. the scientific policies of our own government). The actual length of the solar year is a little less than 365.2424 days. Thus the first of Thoth, the Egyptian new year's day, would slip slowly through the seasons over the centuries. We approximate the new year by an added day every four years except on the first year of the century. Thus, we get a year of 365.24 days (which can be made even nicer by making the first year of every fourth century a leap year except for each

10th millenial year). But a year of 365 days would slip noticeably over the centuries. The coincidence of summer solstice and the first of Thoth would occur once every 1506 years (365 divided by [365.2424−365]). Every four years the solstice would occur a little less than one day later in the legal Egyptian year. Such a seemingly crude calendar, foolish when the solar temple exists, would appear at first a typical administrative blunder, if the purposes of the Egyptians were the same as ours. But Lockyer points out that we need not assume that purpose any more than we assume legal timing to reflect the science of today. In fact, the Egyptians had a "long" year, the Sothic cycle, which lasted 1461 legal years. This seems a peculiar period, given the accurate coincidence of solstice and the first of Thoth every 1506 years. And it smacks of approximation, since 1461 = 4 × (365¼) or four times the length of the year we presently use. Here an astonishing new story emerges.

The word "Sothic" refers to Tothis or Hathor as the star, Sirius (Sept), which is of first magnitude — i.e. among the brightest in the sky. In treating the use of this star, we are brought to the precession of the earth's axis. Consider the earth as a spinning top, moving in orbit around the sun, and take the motion of the top not with respect to the sun but instead in relation to the stars. Besides its spinning (which is the daily round), a top has two other motions. First is a changing tilt, which tilt earlier was called the "obliquity." Second is the circular wobble at that particular tilt, which is called "precession." In the simplest pictures of the earth going round the sun, the earth keeps its axis fixed with respect to the stars. But in fact this axis is not fixed, instead it has a slow wobble that takes 25,667 years for a full cycle, for the axis to come back to its original direction (given the change in obliquity). This is a long time for us but not a long time for astronomy. Since our obliquity is 23½°, the "fixed" point in the heavens toward which our axis points will shift in a full 47° diameter circle over 25 millenia as shown on page 53. Over the lifetime of a man, or in a few centuries, the pole star, the unmoving point in the heavens, will seem fixed. But then it will take on a noticeable circular motion in the night sky and eventually a new star in the precessional path will become fixed. Indeed, to the patient eye of an astronomer, the stars describe wreaths in the sky, as one pre-Socratic wrote. Giorgio de Santillana and Herta von Dechend have given the mythic strength of this discovery in their book, *Hamlet's Mill,* which is about the precession of the equinoxes.

How does this relate to Sirius? The sun was not the only light to set the year. Each day, as the sun rises, the view changes of those stars that rise at the same time then fade against the increasing daylight. The rising of a star over the horizon at sunrise is called the "heliacal rising." Sirius, one of the brightest stars, rises heliacally at the summer solstice (seen from the latitude of the Elephantine). It, too, was a marker for the solar year. At the time that Sirius was used for year-marking, it was precessing at a rate almost exactly the difference between the true solar year and 365¼ days. The heliacal rising of Sirius at solstice, therefore, occurred every 1461 years because of that precession. So Lockyer maintains, and I find the argument persuasive. The Sothic cycle is tied to Sirius by other scholars such as Biot and Oppolzer (to whom Lockyer refers extensively). Lockyer reasonably proposes the legal year and the Sothic year as a kind of Vernier measure of dynastic time.



Plan of the temple of Amen-Ra at Karnak, Egypt, taken from The Dawn of Astronomy, by J. Norman Lockyer. A stone avenue runs through the center of the ruins, oriented from southeast to northwest. Apparently the temple included a long series of apertures, which collimated the light entering the sanctuary at the top of the illustration.

Finally, as if to cement the story, Lockyer looks at the star temples and finds them rebuilt and rebuilt again. And the newer ones are always at a slight angle to the older ones. Classically the Egyptologists have accounted this to a prejudice against regularity, called symmetrophobia, almost the opposite of the Pythagorean spirit. But Lockyer, quite cleverly, shows that the same change could be accounted by the precession of the stars collimated and presumes to date the rebuilding thereby.

I will leave off at this point and not retell the less interesting speculations of Lockyer about the religions of Egypt. I am told that they are wrong. What I have given so far sets the question of how the considerable amount of empirics necessary to the astronomy was carried out. We know that to construct the temple the king first "stretched the cord," keeping his eye on the rising star or sun. But we don't know how that day was set and how the knowledge leading to it was accumulated and passed on.

Lockyer's suggestion is bold. It is that the structure of the myths maps celestial events. A myth, to him, is a mnemonic with respect to a natural science for which no abstract language has yet been developed. That the myth becomes ritual ensures the passage of the knowledge. That it is told without explanation in the religion does not alter its character. He is not alone in proposing this idea.

The notion of myth as a world-view, not only in the vague mystic sense (which is not denied) but in the prescientific sense appears to have angered the establishment in the history of science. Indeed, when Lockyer's book was reprinted by the MIT Press (from my copy), two very eminent historians wrote in, practically severing relations with the publisher. But Lockyer's point does not seem that bad. Here we have, says he, a variety of what definitely appear to be astronomical gadgets — temples — and a sophisticated measure of time in which a conventional year and a measured year beat against each other. Where, asks he, are the specifications for putting up and using the temples — what are the data used — how are they got? The old Egyptians, whose arithmetic is clever but primitive, have no knowledge of angles, no theory of light passing in a straight line, no words for relative position in the sky, and so on. Not much is needed to lay out the solstitial avenue or the star sighting. Not much, but something considerably more than a whim. How is that knowledge carried? How does one instruct a novice? Or a king? All the material that is related to the temple deities is in the form of myth. Can it not be that the relations in the myths map the needed time and position relations of celestial bodies?

Oddly enough, this speculation seems most offensive. In part the reason is clear. If we relax the rigorous rules of historical research, any fool can come along and propose that Bacon wrote Homer as well as Shakespeare. Velikovsky can be taken seriously. There is no end to the mischief. And so the feeling against Lockyer is strong, for he can offer no proofs — only a suggestion that he takes too far. Well, any speculation can be taken to absurdity, but yet the germ may be interesting and proper. I have seen no criticism of Lockyer's technical treatment of the temples, nor any reason for dismissing his idea about the use of myth.

I have introduced myth by the story of Lockyer in order to show a problem. There is little doubt of the astronomic reference in at least some myths. But while the naming of stars can be granted, the specific use is always in doubt except as supported by writings. Without explicit accounts no strong chain can link the artefacts to the tales.

We who learn to read and write before we master any other skill, prize above all things whatever is inscribed. Ancient thought lies in the works of those who published and perished. The great problem is to set the meanings of the words. Here we are guided by the fashion of those who observe animal behavior. We never attribute more intelligence (or knowledge) than just enough to account for the behavior. This rule, so common and dreadfully wrong in social action, is the Procrustean measure for judging the past. But it is necessary if we are to know the past with any confidence.

A principle of least meaning may be just, but it is also unfair. Certainly it leads to severe abuses such as those of Carl Jung, who, by reducing many different texts to a set of common vague forms, rids us of having ever to interpret specifics. Jung is almost acceptable, because he diminishes possible meaning — Lockyer is taboo, because he increases it. Otto Neugebauer, author of *The Exact Sciences in Antiquity,* represents an optimum of sorts, because the fragments he treats are so explicit as to resist the psychological or Jungian degradation. But these are works of mathematics and technology and are almost never concerned with natural history. And this is the rub. In the Western development, up to Aristotle, there are very few empirical accounts of the natural world. Yet there are the beginnings of abstraction, as in arithmetic and algebra, and there are techniques that imply careful observation. Where are the observations themselves recorded?

Before the skill of writing came the art of remembering.

Plato tells of Thoth bringing to the Pharaoh the invention of writing. And the Pharaoh says that remembering will be lost now that anyone can carry his knowledge on paper.

There is almost no indited history of remembering. At most we have anecdotes from antiquity and a late book on rhetoric improperly ascribed to Cicero. Frances Yates tells us of what little material there is in her first chapters of *The Art of Memory.* Why should there be a written account of what needs no text? Even today, the mark of the professional — the mechanic, musician, physicist, physician, take what discipline you choose — is a profound memory for the details of his craft. Yet few tracts deal with this prior and collateral art.

For my purpose I will distinguish two types of memory, the specific and the systematic. Borges describes the first in pure state with "Funes the Memorious" for whom every event could be recalled, every particular, the exact position of every separate leaf on a tree at noon and the exact position an instant later, and how the light reflected from each leaf at one instant and the other, how the wind blew at each time, and the next, and so on. None of it is brought together — it is only an immense file of data unconnected by judgments.

The number theorist, Hardy, describes the second type in his anecdote about visiting the dying Ramanujan. Hardy notes the license number of the cab that brought him to the London hospital and remarks to Ramanujan that it is 1729 and how uninteresting a number it is. But Ramanujan replies that, on the contrary, it is the first number that can be expressed as the sum of two cubes in two different ways. And Hardy is terribly moved, for he sees that Ramanujan knows numbers as we know our friends, each set off by fine yet important distinctions.

To Funes the world is a sheaf of sense-data subscribed for time and place. For Ramanujan the numbers are a created universe in which each mirrors in its own way the necessary design of all. Funes is not as fabulous as he sounds. The ancient scribes of the Torah could be told a letter in any word at the beginning of the scroll and then give what letters would be intersected through the whole scroll by a pin thrust through the given letter. Ramanujan is not as unusually God-like as he sounds. Many music lovers can, on hearing a single chord or a succession of two or three notes, identify the composition being played — for they hear not only the sounds but the pauses, the attack, the style, which are the unwritten parts of the music.

In our own memories we play Funes and Ramanujan, sometimes isolating a particular and sometimes reflecting in it the whole, as Leibnitz conceived for the monads. The world, in our memory, is given by an aesthetic playing

that only rarely is inscribed. (Hilbert, the mathematician, once complained that reading a published work is like seeing a man at the top of a snowy mountain who has swept away his footsteps with a broom and stands there smiling, saying, "Guess how I got here.")

How did one remember before writing became common? *The Rhetorica ad Arrhenium* gives a variety of ways that were already ancient then. One had walked alone and slowly through a familiar temple, learning the sequence of patterns in the marble, the order of stones underfoot, the crevices, niches, insets and gaps, the reliefs, protrusions and sculptures, the details of the pediments, the fluting of columns, the Karyatids, the views from different vantages, in short, the temple as a thing rather than an idea. This memorable structure lies in the mind as a form through which an imagined walk can be taken. To each familiar detail one attaches a line of poetry, a point in a legal argument, a thread of reasoning. From the Greek τοπος = place, comes the English word topic — a commonplace proper for many treatments. (What is your topic, Isocrates — what nook shall we festoon with discourse, strolling a new path down memory's lane?)

Or else one weaves a story in which accidents turn necessary and causal as we experience in the rue that attends disaster ("Had I but turned right rather than left — had I but stopped and waited —"). Yet one does not need disaster to invent a connected process, only practice or paranoia.

Or else one constructs refined tricks of language to hold, in their design, hints to the corpus to be remembered. Medical students learn the sequence of cranial nerves by recalling "On old Olympus' towering tops a Finn and German viewed some hops." Or they are reminded of the metacarpal bones in the proper order by "Never lower Tilly's pants; mama might come home." The initials of the mnemonic are the initials of the nerves or bones. Somehow the foolish (but not nonsensical!) cantrip and the stuff to be recalled become fused, and through the magic of the chant the proper names are had.

Or else one makes use of rhymes and meters, puns and bizarreries, figures of speech, even hiatus or aposiopesis, so that the pattern of the language carries a map of the memorable. Not only Shakespeare and Homer and the Bible carry whole views of the world, but nursery rhymes and bar-room ballads. (Remember Mark Twain's "Punch, brother, punch with care, — punch in the presence of the passengaire." That, even now, brings the smell and click-clack of long-dead trains.)

So great are the amenities of language and so varied the views of the world that one can slip into a perspective with ease and be reminded in one role of events that are impossible in another role. Method memory, a Stanislavskian immersion in a mutable past, is more our practice than careful history. A depressed person recalls only the slights and misfortunes, an elated person is reminded of the triumphs and joys. On the frame of reference at the moment, the dead past events hang like thieves on a gibbet or are plastered like pictures in a scrapbook. I am not talking of this personal memory but of a partially public one in which the details of a crime can be set to a song, and a song hold the exculpation. There is, not a racial, but a public memory that is bound with the spoken word and is understood in a way very different from the store of knowledge in Thoth's invention.

Not I, but the author of the *Rhetorica* (somewhat exuberantly amplified here) sets the function of temples and tales in imaging the past and arranging the details and connecting empirics. Our natural language as much as our other arts is notation for the perceived world and evolves to fit it.

It has often been remarked that the great advances in mathematics and logic are principally notational. The concepts, however grand, must reduce to a lawful way of arranging symbols, or they are useless. It doesn't matter what goes on in the mathematician's mind as image or simply pure feel, what counts is the choreography of his marks. And it isn't even the marks but only the rules for arrangement that are important. To Hilbert in the railway café it was revealed that it makes no difference whether one uses x's and y's or beer mugs and tables. This abstract set of rules evolves almost in animal fashion, growing into every possible niche of inquiry, developing species and genera of discipline, becoming a tree of *a priori* knowledge.

We are quite willing to accept this evolution of logic, but we are reluctant to allow the notion of a myth as a richer-growing cluster of relations that deals with the perceived world. There is, of course, one obvious difference. Logic and mathematics treat with truths sub specie aeternitatis — permanent verities, however voiced and under whatever conditions. This changelessness guarantees recognition, and only permanent truths can be translated intact without reference to time and place and person. But natural history is concerned with contingent truths that depend not only on observation but on the language conventional to perception at the time and in that place and on a host of other conditions on the observer. And this generates the Catch 22 of scholarship aside from the history of science, military adventures and the accounts of administrators. You can't even guess what is meant unless you know what is meant.

Lockyer, more than anyone else, introduced the notion of mapping a myth. Although he was far from careful and even generated some absurdities, the method is clever and plausible. It does not prove, but instead persuades. The technique is simple. Suppose I have a set of objects in a museum and a set of labels in an unknown tongue. The only information that I have is that the labels are associated with the objects. Now I go about assigning labels to objects. What I look for are relations between the labels that correspond to the relations between the objects. Suppose that there are ten vases, and no other kind of thing has ten examples. If I find ten labels alike and no other set of ten like labels, it seems reasonable to assign, provisionally, these labels to the vases. Then suppose there are two stuffed animals, one male, one female. I can find no pair of like labels, but I find a pair that are similar in inscription. Etc., etc. This is the way that codes are cracked, dead languages read, and murders solved in detective stories. If, after a while, I find that I can assign a label to every object by a set of rules rather than simple whims, and there are no objects or labels left over, then I have a good map of objects in labels and labels in objects. The map is good if the rules are few and bad if the rules are many, worst if a separate rule is needed for every pairing of object and label.

This method of mapping is precisely that which is used by such historians as Neugebauer to decipher the mathematical works of antiquity. Once one grasps that the relations between curious ancient symbols are also the relations we have in arithmetic, a translation is possible. Had Neugebauer dealt with slab after slab of failed examina-

tion papers of an arithmetic class in Sumeria, he would hardly have succeeded. The work was enormous, but success was guaranteed, in a sense, by the nature of mathematical truths.

Not all maps can be that good, particularly if one is dealing with experiences rather than abstractions. Then the language is much less definite. (I recall how long it took me in the clinic to learn that when an old Albanian complains that the devil blows hot and cold on him, he is telling me that he has malaria.) Natural language is ambiguous in various ways that are only heightened, not invented, by poetry. One need only read the philology pertaining to antiquity to realize how slippery is the footing. The art of mapping myth rather than mathematics cannot rest on the texts alone but must refer to what the texts mean with respect to the perceived world. The laws of talking about perceptions have changed drastically, and so, in a sense, have the perceptions themselves.

Here is where Lockyer and his successors, such as de Santillana and von Dechend, incur at worst the contempt, at best the amused toleration of scholar scientists. There is no internal way of deciding, as for arithmetic, the meaning of fragments from the past that concern them. Their method of mapping permits metaphors whose rules are vague. (A great rabbi was famed for his utterance — "Life is like a river." At his deathbed one of his students asked him the meaning of this comment. The rabbi thought, and, as he died, said "All right. Life is not like a river.") The language becomes like fluid in their hands. And for a while it almost seems that for them, as for psychoanalysts, any meaning can be couched in any terms. But finally, unlike the study of dreams and other private matters, there does remain a stubborn and public exhibit that must be accounted. In the case of Lockyer and de Santillana and von Dechend, it is the indisputable knowledge of astronomy evident as much in the temples as in the rituals. To have such a knowledge passed on through many generations, a knowledge that is, in fact, central to the religion in the matter of careful timing of holy days, and yet have no vestige left of its verbal form, seems unreasonable, given that laundry lists, kingly boasts, and the sad prose of generals for some reason survive.

Lockyer's way to map a myth is straightforward. Since the astronomy could not have had our language of angles, declensions, ecliptics and the like, there must have been a language for coincidence and sequence and other simple relations. So, for example, if Sirius rises heliacally, this could be represented by Isis suckling Ra, the animal relation expressing the needed anteriority of Sirius to the sunrise. And the idea is to move through myth as such metaphor to seek the knowledge implied by the existing artefacts such as calendars and temples.

The danger of this procedure is obvious. Probably the worst feature is that there is no way to tell that one has gone too far. And so the enthusiasts (and anybody who undertakes such work must be one) invariably go too far. But why such a fuss about excess? The notion of myth as a mnemonic for celestial relations is most compelling, seeing that no other kind of expression offers itself. It certainly fits with the temples and tales as the art of memory in antiquity. Plato tells us that the gods are stars, and he does not claim to have invented the idea. If one must have the gods related to each other to do astronomy, what better, more familiar, and definitely most memorable relations than those of which we are daily reminded — birth and death, nursing and loving, pursuing and fighting? And so the essence of humanity becomes the abstract tongue for describing events in the sky. How else would there be a way of remembering without writing? And once writing begins, how better to preserve the knowledge than to use the language in which it is already given?

Obelisks near the oldest part of the temple of Amen-Ra at Karnak.

Even so, human relations are complex enough to be an ink-blot against which we can see almost anything we wish, from the precession of the equinoxes embodied in Hamlet to five o'clock in the afternoon personified by the Medusa. This can be advanced as the case against Lockyer and company. But the obverse is that the basic technique of mnemism, of remembering, is precisely such an ink-blottery, and it is not a major criticism to say that the patterns found may reflect the interpreter more than the material. Who would deny it?

Jerome Y. Lettvin has been a pocket-pusher in the cleaning industry, an electroplater of golf clubs, sub-assistant writer of horror movies in Hollywood, psychologist of sea sickness, electroencephalographer, designer of lie detectors, and nurse for an octopus colony. He became an uncouched psychiatrist in 1951 and has since been teaching experimental epistemology in the Research Simulation Center at the Massachusetts Institute of Technology. His previous publications have been in *The Chicago Evening Post, The Chicago Daily News, The Interne, Politics, New Directions, The Fat Abbot,* and *Proceedings of the Institute of Radio Engineers.* Among his successful inventions are a cure for dysmenorrhea, a device to foil wiretapping (with Bradford Howland), and a new way of aerating aquarium tanks. This article is taken from the first chapter of *The Head on the Shield of Pallas,* to be published by Gambit Press.

Hans A. Bethe
Laboratory of Nuclear Studies
Cornell University

Gravity and nuclear fusion can begin to explain the progression from normalcy to supernova

The Energy of the Stars

As soon as people began to search for scientific explanations of natural phenomena, I'm sure that they wondered what makes the sun and other stars shine. In the middle of the last century, Helmholtz and Kelvin suggested an answer. After all, they argued, there is gravitation: a lot of energy is set free when mass is collected from a large distance to assemble the sun. The total figures out to be about 2×10^{15} ergs per gram of the sun's material. Now every second the sun radiates about two ergs per gram; dividing one number by the other, one finds that the sun can radiate for 10^{15} seconds, or 30 million years. That result was fine when Kelvin and Helmholtz made the calculation. In fact, it was a greater longevity than anyone had imagined before. But not so much later, we learned how to estimate the age of the earth, and we now know that number very accurately. It implies that the age of the sun is at least 5 billion years, which shows that Helmholtz and Kelvin were wrong. Gravitation cannot provide the energy of the sun nor of most of the other stars. What then is the source of the energy?

Faint to Brilliant, Cool to Hot

The figure at the right displays the properties of stars in the form of a so-called Hertzsprung-Russell diagram. On the abscissa, the stars are plotted according to their color, which indicates the surface temperature — about 3,000 to 100,000 degrees. The ordinate shows the luminosity, which is usually given as a multiple of the light from the sun. Thus our sun sits at one in luminosity versus about 6,000 degrees in surface temperature, placing it in the midst of a large number of stars that form a progression known as the Main Sequence. The sequence ranges from very brilliant and very hot stars, the Blue Giants, having energy outflows 100,000 times that of the sun, to very faint and cool stars, the Red Dwarfs. There are also stars outside the Main Sequence: the Red Giants, which are cool but very luminous, and the White Dwarfs, which are the opposite — faint, but fairly hot.

The upper figure on page 60 gives the relation between luminosity and mass for Main Sequence stars. The abscissa is the mass divided by the mass of the sun, on a logarithmic scale ranging from stars 100 times more massive than the sun to stars of one tenth the mass. Luminosity rises incredibly from one end of the chart to the other; it is tremendously dependent on the mass of the star. In the Main Sequence, the brilliant stars are presumably stars of larger mass, and in those cases where we can measure the mass, we find that this is true. (The figure, of course, is based on those cases where the mass is measurable). Stellar radius, on the other hand, varies very little as stellar mass changes. Generally, the radius is a little less than proportional to the mass.

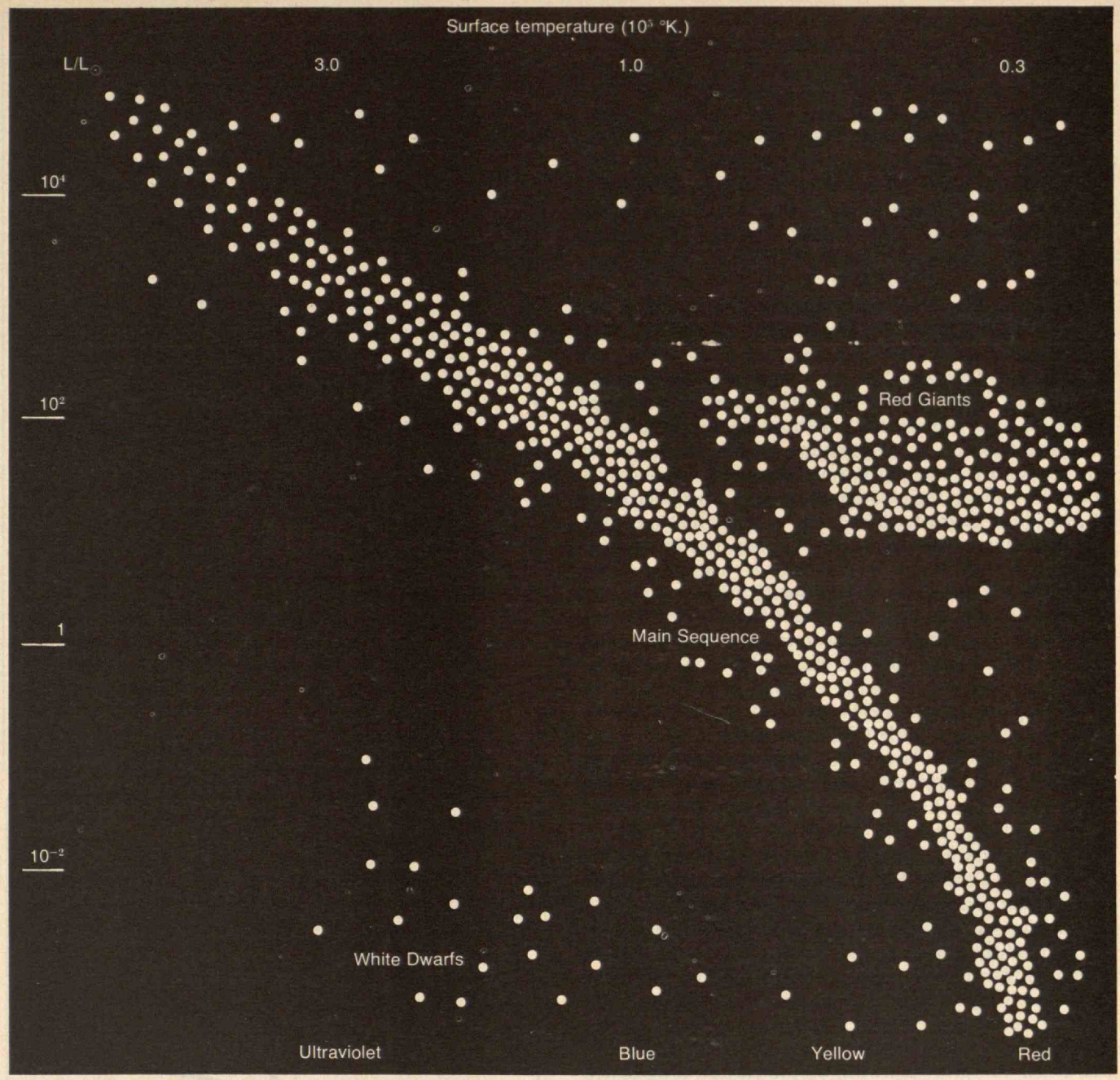
What can we say about the internal constitution of the stars? In the 1920s, Eddington showed how to calculate the internal constitution from very simple laws of physics. The first of these laws is that of hydrostatic equilibrium: at any point in the star the pressure is equal to the weight of the material above, just as in the earth's atmosphere. The second is the law of radiation transport, which predicts how radiation moves from the center of the star, where it is produced, to the surface. With this knowledge, modern computers can calculate that the temperature at the center of the sun should be 14 million degrees Kelvin. One important point is the mean weight, relative to hydrogen, of the atoms in the sun. Common stars contain about 70 per cent hydrogen (by weight), 30 per cent helium, and traces of heavier ions from carbon to iron.

The Carbon-Nitrogen Cycle

In the 1930s it became accepted that the source of a star's energy was probably nuclear reactions. By 1938, we understood enough about nuclear reactions that it seemed possible to calculate their rates, and in this way learn which reactions were the most important.

Nuclei are electrically charged, and in consequence there is an electrostatic potential between them, which is proportional to the two nuclear charges and inversely proportional to the distance separating the two nuclei. In brief, the nuclei repel each other, but according to quantum mechanics the potential barrier can be penetrated and a reaction between the two can occur. The probability of the reaction has a temperature dependence: the harder it is to penetrate the potential barrier, the smaller is the probability of the nuclear reaction, but the more strongly does it increase with increasing temperature. (Another factor enters the calculation, though. It is called the intrinsic probability, and varies very strongly from one nuclear reaction to another.)

Knowing all this, it becomes clear that the reactions which will take place most easily are those involving the smallest nuclear charge. Therefore, the obvious interaction is that which involves two hydrogen nuclei — that is, two protons. The only thing two protons can do with each other is make a deuteron. In this reaction a positron and a neutrino are emitted. The process was suggested by Von Weizsäcker early in 1938, and then calculated by Critchfield and myself. We got a result which was very close to the energy production in the sun. Of course, once



The nature of stars is displayed on a Hertzsprung-Russell diagram, in which a star's surface temperature is plotted against its luminosity (the luminosity of our sun is taken as unity). A so-called Main Sequence runs from the upper left to the lower right of the chart; massive stars tend to be more luminous and have higher surface temperatures, placing them toward the left of the sequence. Two groups of stars fall outside the Main Sequence: the Red Giants and White Dwarfs.

the sun has made a deuteron, that deuteron can capture another proton and then still another. The final result is that four protons come together to make a helium nucleus, which is very strongly bound. Two positrons are emitted (later to be annihilated with negative electrons) and also two neutrinos, which escape. The trouble with this reaction is that while it gives about the right energy, its probability rises only as the fourth power of the temperature. Now Eddington's work showed that the central temperature doesn't change very much with the mass of the star. On the other hand, we know that the luminosity increases tremendously with the mass of the star, and therefore we need a reaction which depends much more strongly on the temperature.

I searched in the periodic table, assuming still that one of the interacting nuclei is that of hydrogen, and found that helium, lithium, beryllium, boron — all are no good. But then, I landed at one which is indeed very good, and that is the interaction of a carbon 12 nucleus with a proton. This is the first reaction of the carbon-nitrogen cycle:

$$
\begin{aligned}
C^{12} + H &\rightarrow N^{13} + \gamma \\
N^{13} &\rightarrow C^{13} + e^{+} + \nu \\
C^{13} + H &\rightarrow N^{14} + \gamma \\
N^{14} + H &\rightarrow O^{15} + \gamma \\
O^{15} &\rightarrow N^{15} + e^{+} + \nu \\
N^{15} + H &\rightarrow C^{12} + He^{4}
\end{aligned}
$$

(γ represents a gamma ray, ν a neutrino, and e^+ a positron.) In the end, the cycle reproduces the carbon, which is a good thing because carbon is a rather rare element in stars. The reactions use up only hydrogen, which is the most abundant element in stars, and again end up by combining four protons to make helium-4, two positrons, two neutrinos, and a few gamma rays which are then converted into thermal energy. I found to my surprise that the carbon cycle also gives about the correct energy for the sun, but that it has a much stronger temperature dependence: it varies as about the 20th power of the temperature.

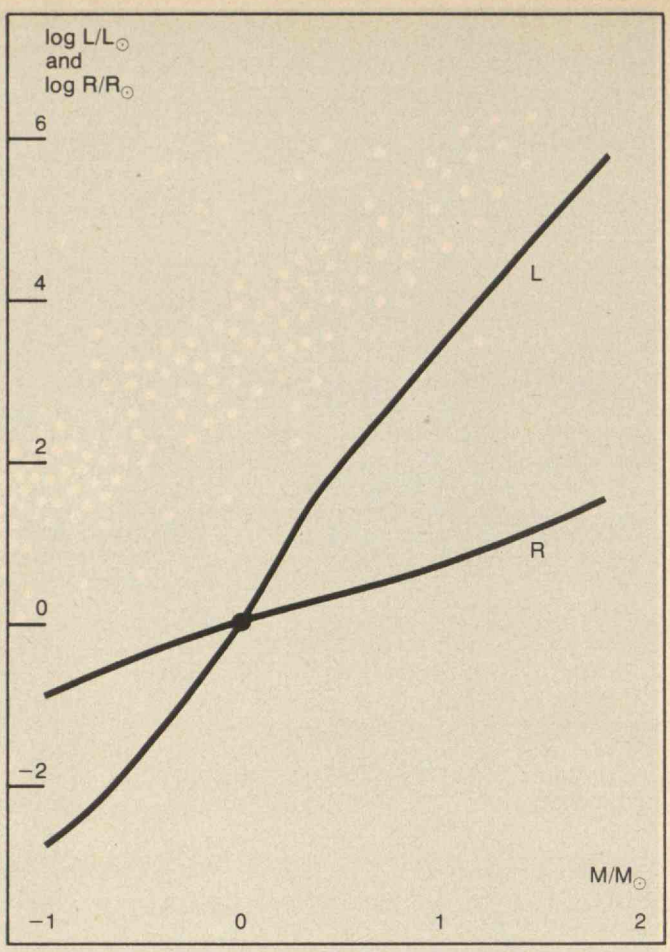
I then estimated the probabilities of the reactions, and came out with figures which were quite reasonable. But it is, of course, always better to do an experiment than rely on a theory. This was done over a period of many years by William Fowler of Cal Tech. The lower figure on this page uses some of his results. It shows the energy production, as a function of temperature, for the proton-proton reaction and for the carbon-nitrogen cycle reaction. At about 17 million degrees, the two curves cross. The sun is at 14 million degrees, so as far as that star is concerned, our first guess was right: the proton-proton reaction supplies most of its energy. But consider a star like Sirius, with a central temperature of about 20 million degrees, or the really brilliant stars, which may be at 30 million degrees. Here one finds energy productions which can easily be 10^5 ergs per gram per second — this at temperatures only about twice the central temperature of the sun. So everything is fine, and the energy production in the Main Sequence can be considered as explained.

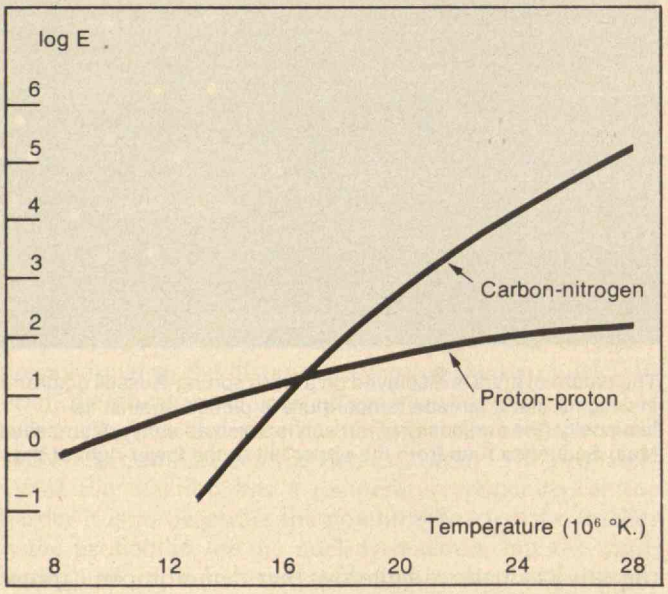
There is only one flaw in this: as we previously showed, there ought to be neutrinos coming out of the sun. Ray Davis of the Brookhaven National Laboratory has been trying to detect these in a deep mine in Montana for about ten years. He has found less than one tenth of the number of neutrinos that ought to be there. This is a terrible puzzle. Nobody doubts that the general theory of nuclear reactions is correct; too many of its predictions are verified by observation. The question of the missing neutrinos is a detective story which has not been solved so far.

Red Giants

For either the proton-proton or the carbon-nitrogen interaction, hydrogen is consumed in the center of the star where the temperature is highest. What happens when the hydrogen is gone? Calculations on this subject were started by Schwarzschild at Princeton, and are essentially his life's work. The particular calculation shown on the facing page, however, is due to Icko Iben, who at one time was at M.I.T., and is now at the University of Illinois. It refers to a star of mass three times the mass of the sun, and shows that for a long time in its life — 231 million years — that star behaves quite decently. It stays at about the same central density: 40 times the density of water. But then it suddenly goes on a rampage. Because it has used up its hydrogen in the center, it lacks the central energy production that held up the stellar material. Therefore the strongest force in the stars — gravitation — takes hold. The center of the star collapses to a density of some twenty thousand grams per cubic centimeter. The central temperature also changes dramatically. It had been constant at perhaps 25 million degrees, but then it goes through some wiggles and rises tremendously.

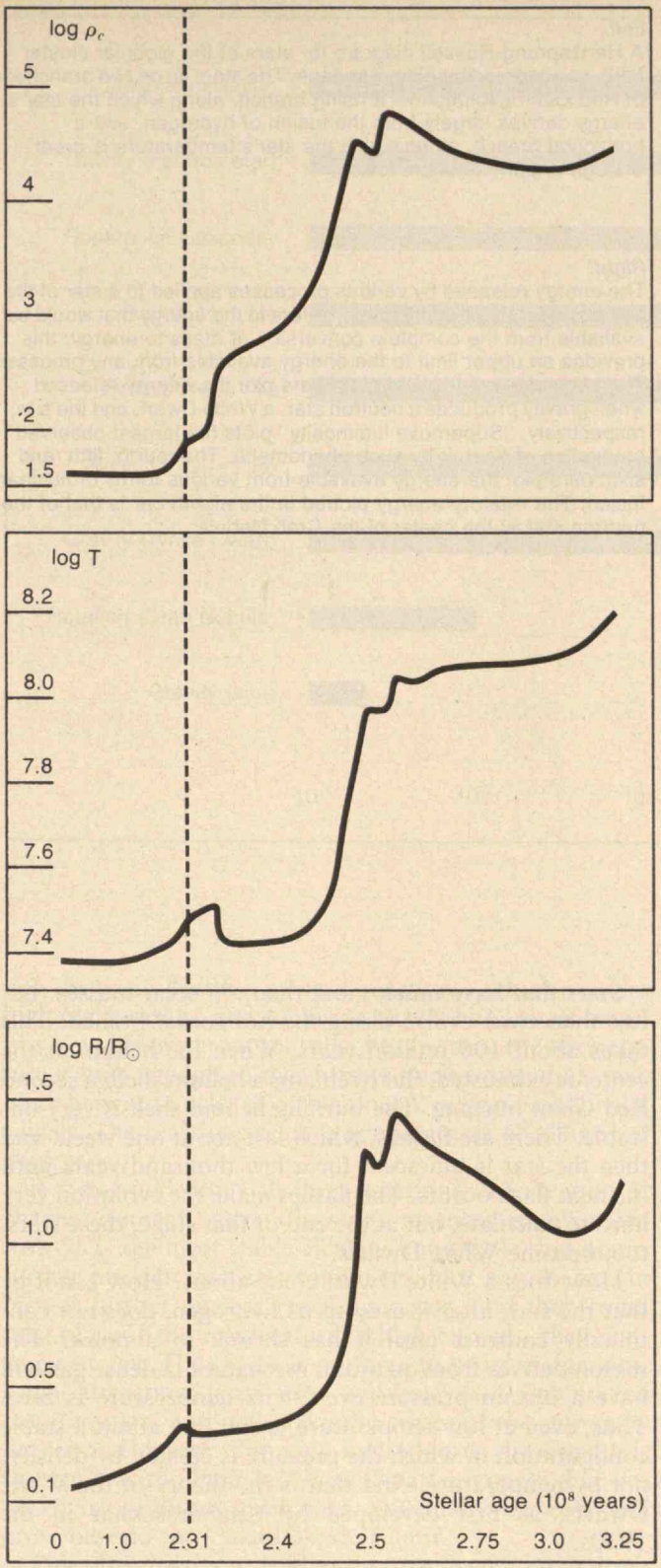
The density and the central temperature are of course





Top:
Stellar luminosity and radius, as functions of stellar mass. A star's luminosity is seen to be strongly dependent on its mass, while its radius is slightly less than proportional to its mass. The axes in the chart are all logarithmic, and have been scaled so that our sun's mass, radius, and luminosity all have values of one.

Bottom:
Two sources of energy in Main Sequence stars are compared. Both sources involve nuclear fusion: the first is a reaction between two hydrogen nuclei to form helium, and the second is a series of reactions called the carbon-nitrogen cycle. The contributions of the two are equal for a star whose central temperature is about 17 million degrees.



The evolution of a star three times as massive as the sun, according to calculations made by Icko Iben. The star is fairly stable until it has depleted the hydrogen at its core. Then, at an age of 231 million years, its central density increases (top chart) as gravitation causes this region to infall. The central temperature also increases (middle chart), and the temperature in outer regions of the star rises until hydrogen fusion begins to occur there. The process of energy transfer from this new region of energy production causes the radius of the star to expand (bottom chart) as the star becomes a Red Giant.

related: as one compresses a gas, its temperature increases. But there is a third line in the figures which tells the real story of these stars. When the hydrogen in the center is gone, there is still lots of hydrogen outside the center. And since the star has collapsed, this outside region becomes hotter than it used to be. At some distance from the core of the star, the temperature reaches 25 or 35 million degrees. There is still hydrogen here, and therefore in this outside region energy production occurs by the same reactions that had powered the center — essentially the carbon-nitrogen cycle. But these reactions now take place in a shell of matter.

The last chart on this page shows what happens to the radius of the star. Initially, the radius is about 1.5 times that of the sun, but then the star does something quite paradoxical. While the center collapses, the outside of the star expands tremendously to about 20 or 30 times the initial radius. It does so because the energy generated by the star has to be transported outside. In order to do this from a thin shell source, it is necessary to have a very large gradient of temperature — larger than it used to be because the energy is now generated in a much smaller region. The expansion ends in the creation of a Red Giant star.

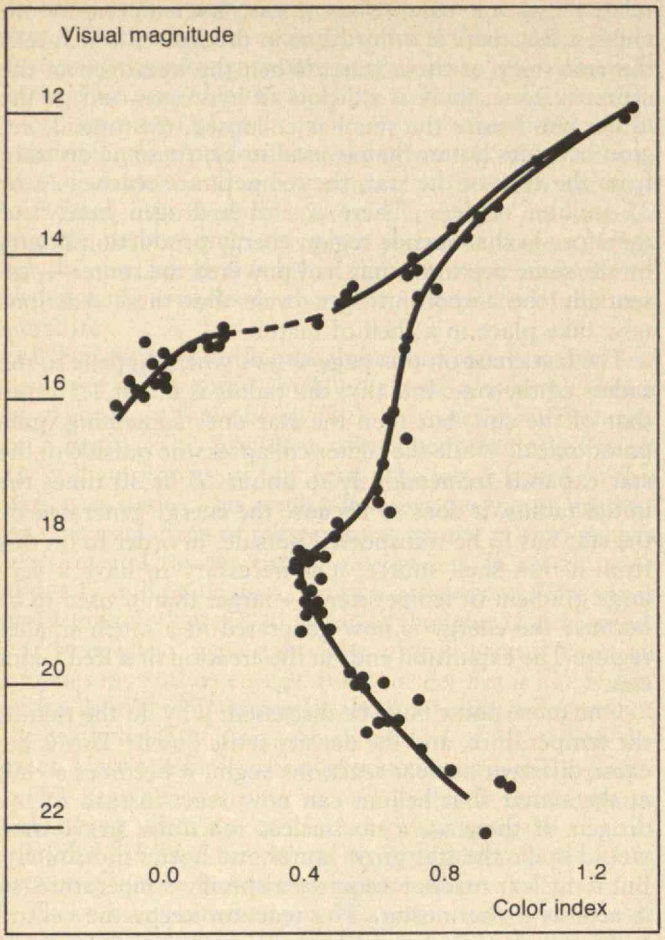
One more point must be discussed: why do the radius, the temperature, and the density settle down? This is because different nuclear reactions begin: it becomes so hot at the center that helium can now react instead of hydrogen. If there were no nuclear reactions, gravitation would make the star grow hotter and hotter indefinitely. But a nuclear reaction requires a specific temperature, so it acts as a thermostat. The reaction keeps the central temperature of the star down, the opposite of what one might naively expect.

The first helium reaction is with nitrogen 14, for the carbon cycle has converted all the carbon and oxygen which is initially in the star into nitrogen 14. The reaction produces fluorine-18, which is a radioactive nucleus, and decays into oxygen-18. This oxygen-18 is very important for the later development of the star. Helium can react with oxygen-18, making neon-22, and neon-22 at a much higher temperature will capture an alpha particle and become magnesium-25 plus a free neutron. The free neutron can be used to build up elements heavier than iron in a gradual process that probably takes place in stars with a mass between three and eight times the mass of the sun.

Another, and more important, reaction of helium occurs when three helium nuclei come together to make carbon-12. This reaction was discovered by Salpeter, who showed that it can occur in spite of the fact that it requires a collision among three particles. This event, of course, is extremely unlikely because the stellar density, although it is 10,000 times that of water, is still very low. That this reaction is possible at all is due to the coincidences that two helium nuclei have nearly the same energy as beryllium-8, and that beryllium-8 plus helium-4 have almost the energy of an excited state of carbon-12. Once it is created, the carbon-12 can capture another helium to make oxygen-16. At 110 million degrees, these reactions can occur and that is why the star's temperature settles down at about 100 million degrees.

White Dwarfs

A star of only .85 the mass of the sun takes about 12 billion years to use up the hydrogen in its center. Now the oldest stars we know are just about 12 billion years old,



Left:
A Hertzsprung-Russell diagram for stars of the globular cluster M92, as observed by Allan Sandage. The stars lie on two branches of Red Giant evolution — a rising branch, along which the star's energy derives largely from the fusion of hydrogen, and a horizontal branch, along which the star's temperature is great enough to permit helium fusion.

Right:
The energy released by various processes applied to a star of the sun's mass. "Mass annihilation" refers to the energy that would be available from the complete conversion of mass to energy; this provides an upper limit to the energy available from any process. The second, seventh, and ninth bars plot the energy released when gravity produces a neutron star, a White Dwarf, and the sun, respectively. "Supernova luminosity" plots the largest observed production of energy by such phenomena. The fourth, fifth, and sixth bars plot the energy available from various forms of nuclear fusion. The rotatory energy plotted in the eighth bar is that of the neutron star at the center of the Crab Nebula.

which is approximately the age of the universe. These very old stars can be observed in so-called "globular clusters"; they are known to have a very small content of heavy elements, and this changes their evolution somewhat from that of the sun and similar stars. Still, in a time on the order of a hundred million years, they go through an evolution in which their luminosity and their radius increase tremendously. And so they enter the Red Giant stage.

The figure above displays observational data on one of these globular clusters, as observed by Sandage. The figure suggests that there are really two different Red Giant stages. At first, an evolving star augments in luminosity and in radius. But it may then enter a so-called horizontal branch of stellar evolution. The story is this: Along the rising Red Giant branch, more and more mass of the star is enclosed inside the shell of burning hydrogen. When the mass inside the burning shell is equal to .45 of the sun's mass, the temperature at the center becomes high enough for a helium reaction to take place. Then, as we have seen, the central temperature and the luminosity settle down. The star now shrinks in radius. Hence the surface temperature rises; the star goes from red to a color like the sun's yellow. The horizontal branch, then, is explained by the ignition of helium at the center.

This can happen only if the total mass of the star is at least .45 times the mass of the sun. If it is less than .45 the star will go quite happily through the Red Giant stage. However, the helium cannot ignite when the star has used up all its hydrogen, so the star simply settles down. It will contract gravitationally, and then it will end its energy-producing life. It will become a so-called White Dwarf.

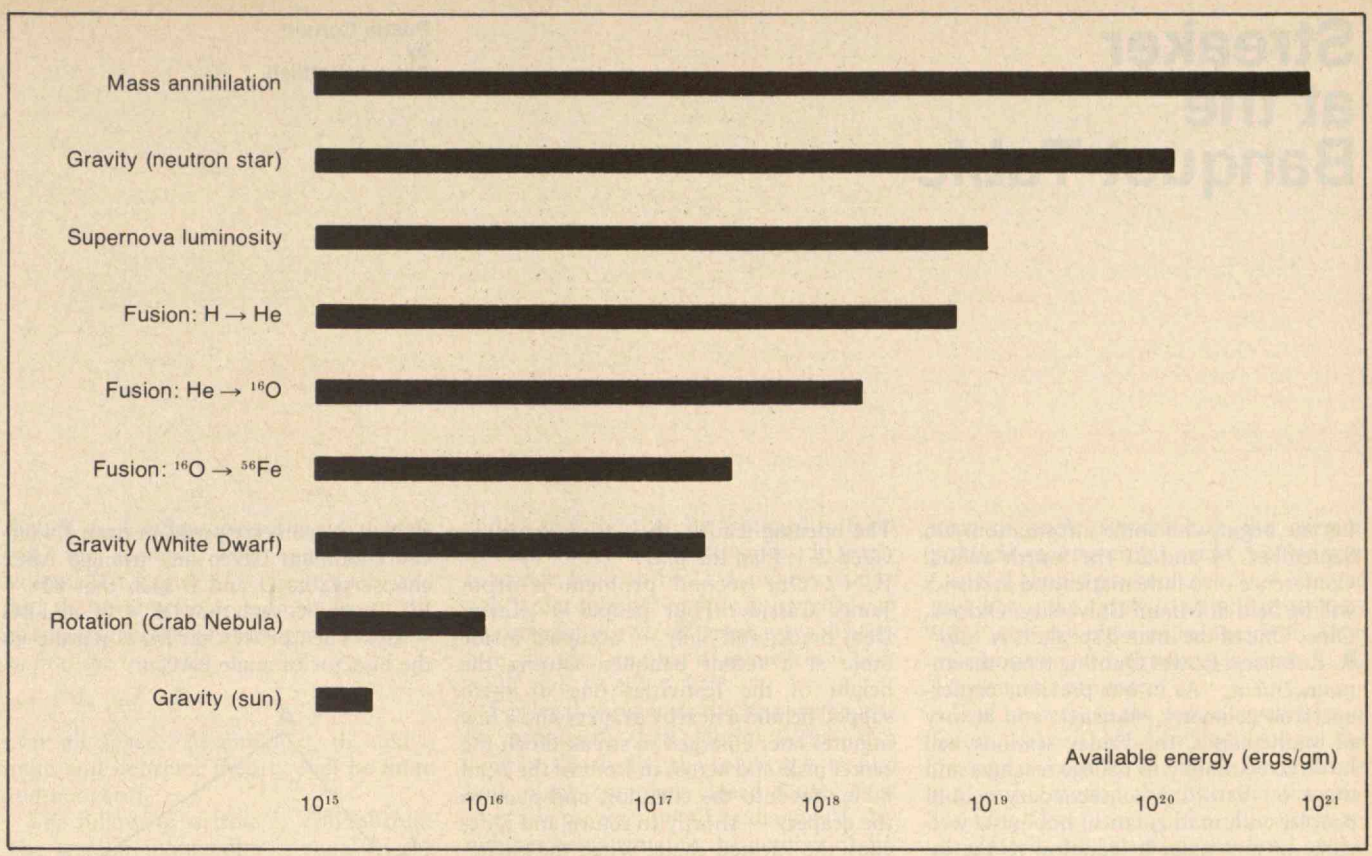
Stars that have much more than .45 solar masses (but less than two) evolve along the horizontal branch. This takes about 100 million years. When the helium at the center is exhausted, there remains a helium shell, a second Red Giant burning. The burning helium shell is very unstable. There are flashes, which last about one week, and then the star is quiescent for a few thousand years until the next flash occurs. The flashes make the evolution very hard to calculate, but at the end of that stage, these stars, too, become White Dwarfs.

How does a White Dwarf come about? How can it be that the star, after it uses up its hydrogen, does not continually contract until it has shrunk to a point? The reason derives from quantum mechanics: a dense gas will have a certain pressure even if its temperature is zero. Thus, even at low temperature, a star can attain a stable configuration in which the pressure is created by density, not by temperature. And that is the theory of the White Dwarfs, as first developed by Chandrasekhar in the 1930s.

Chandrasekhar discovered, however, that this theory has a limit, which occurs when the electrons (it is electrons that make the pressure) attain very high energy and approach the velocity of light. It turns out that a White Dwarf can have at the maximum a mass which is 1.44 times the mass of the sun. In fact the observed White Dwarfs all fall within this limit of 1.44 suns. Many of them have less mass than this.

Neutron Stars and Supernovae

Now the question arises: What happens to the big stars? The centers of such stars contain a multitude of elements, from carbon on up in mass. There is therefore competi-



tion between further nuclear reactions, which require high temperature, and evolution to a White Dwarf stage. It is now believed that for most heavy stars, the temperature is high enough so that further nuclear reactions take place between nuclei of carbon, neon, oxygen, and finally silicon. The reactions require temperatures of billions of degrees.

If a star undergoes all these reactions, the creation of heavier elements generally stops at mass number 56. Iron-56 is the most stable element known. At that point, further nuclear reactions cannot produce any energy. In fact, if further nuclear reactions occur (and they could take place if the temperature is high enough) they consume energy. Thus there is no force to resist the gravitational attraction: gravitation will hold sway unhindered from now on, and will make the center of the star grow denser and denser. The only limitation to the density is the same as the limit in White Dwarfs, namely that imposed by quantum mechanics. Eventually the core will grow beyond the Chandrasekhar limit.

This obviously must lead to catastrophe, and so it does: the whole core collapses into essentially nothing in a matter of seconds. It is now generally thought that this is one explanation of supernovae. In the supernova phenomenon, a dying star radiates enormous amounts of energy — as much energy in a few days as it has emitted during its previous life in billions of years.

The figure above displays the energy available from various sources. As we noted at the beginning of this article, assembling the sun releases an energy of about 10^{15} ergs per gram. If gravitation acts until a White Dwarf star is produced (the White Dwarf's radius being about the same as that of the earth) then the energy set free is about 10^{17} ergs per gram. But in the phenomenon I've just discussed, the star collapses to a radius of about 10 kilometers. The energy set free is more than 10^{20} ergs per gram or about 100,000 times that set free in the case of the sun. In fact, it is a large fraction of the energy which would be set free by complete annihilation of the mass.

The collapse explains the formation of a neutron star — a star in which the nuclei have absorbed all the electrons around them and have been changed into an assembly of neutrons. The theory suggests that the mass of the star should be near the Chandrasekhar limit. After many attempts, it has become possible in the last year to measure the masses of a couple of neutron stars because they are members of binary star systems. The masses of these stars indeed turn out to be about 1.3 times the mass of the sun, just about what the theory leads one to expect.

This, then is the story of a star. In a sense we have come back to the beginning! Helmholtz and Kelvin said that gravitation is the cause of stellar energy. We recognized that this isn't enough: most of the stars we see get their energy from nuclear reactions. When they reach old age, however, the stars again get their energy from gravitation, either a little bit in the case of White Dwarfs, or a tremendous amount in the case of supernova collapse. Helmholtz and Kelvin were right after all. The most prolific source of energy in stars is gravitation.

Hans A. Bethe recently retired from active teaching at Cornell; he is associated with that university's Laboratory of Nuclear Studies. His research has centered on theoretical nuclear physics, with excursions into theoretical astrophysics. In 1967 he won the Nobel Prize in Physics for his discovery of the carbon-nitrogen cycle of nuclear reactions that occurs in the stars. More recently, he has concentrated on problems concerning neutron stars.

Streaker at the Banquet Table

Puzzle Corner
by
Allan J. Gottlieb

Let me begin with some information. On September 24 and 25 the fourth annual Conference on Mathematics and Statistics will be held at Miami University, Oxford, Ohio. One of the invited speakers is "our" R. Robinson Rowe! Quoting from the announcement, "As in our previous conferences on geometry, statistics, and history of mathematics, the Friday sessions will be directed mainly to college teachers and those on Saturday to secondary school people, with mathematical hobbyists welcome at any time. In addition to the invited and contributed papers, there will be open problem sessions, displays, a book exhibit, and films." Questions may be sent to Professor Donald O. Koehler, Department of Mathematics and Statistics, Miami University, Oxford, Ohio, 45056.

On another topic, Avi Ornstein has noticed a miswording of our yearly problem. We prefer the digits in the order 1 9 7 6 — not in numerical order. And please correct M/A 1 by giving East the Jack and 10 of clubs.

Finally, I have received a solution to NS 2. See the solutions section.

Problems

JUN 1 We begin this month's selection with a bridge problem from the "house organ" of the Charles S. Draper Laboratories, Inc. The dealer is North, and East-West are vulnerable:

North:
♠ 4 2
♥ K 10 8 7 6
♦ A J 5
♣ Q 4 2

South:
♠ A Q 10 3
♥ A Q J 9 5
♦ 4
♣ A 8 3

The bidding:

North:	South:
Pass	1 ♥
3 ♥	6 ♥ (!)
Pass	

The opening lead is ♦ 3; trumps are divided 2-1. Plan the play.

JUN 2 Our second problem is from James Cassidy: Four people — Kevin, Deb, Breck, and Sally — occupied a side table at a recent banquet. During the height of the festivities one of them slipped behind a nearby drapery and a few minutes later emerged to streak down the center aisle and across in front of the head table, out into the corridor, and back to the drapery — shortly to return and reoccupy the vacated chair. When the excitement had died down somewhat the chairman of the banquet committee questioned the four to find out who had reoccupied the vacant chair.

Kevin answered:
1. I sat next to Deb. It wasn't her.
2. Breck or Deb sat to my right.

Deb said:
3. I sat next to Breck.
4. Kevin or Breck was on Sally's right.

Breck replied:
5. I sat across from Sal.

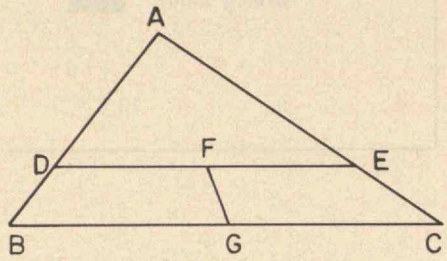
Sally said:
6. Only one of us is lying, and he or she is the guilty one.

Who was the varmint without a garment?

JUN 3 The following problem was suggested by Jeff Kenton: Given a 4 x 4 array with markers in all but one of the squares (as shown); the object is to remove all markers but one by jumping horizontally or vertically (no diagonal jumps allowed), or else to prove that it cannot be done.

X	X	X	X
X		X	X
X	X	X	X
X	X	X	X

JUN 4 A geometry problem from J. Harvey Goldman: Given any triangle ABC, choose points D and E such that BD = EC. Draw FG such that DF = FE and BG = GC. Then prove that FG is parallel to the bisector of angle BAC.



JUN 5 The following problem is from Jack Parsons: A man walking near a lake with a precipitous shoreline sees a girl struggling in the water. He can run twice as fast as she can swim. At what point should he leave the shore to reach her in the shortest possible time? The spatial relationships are: the man is 100 feet from the water, and the distance between the man and girl, parallel to the shore line, is 100 feet. Ground rule: no calculus. (The girl drowns while the man is calculating the best course, but that's irrelevant to the problem.)

Speed Problems

JUN SD1 This one is from R. Robinson Rowe, who says it "should be easy if you know the law 'down under' ": If Ashurst and Bathurst are Aussie neighbors and Ashurst's peacock lays two eggs on Bathurst's land, to whom do the eggs belong; or should each have one?

JUN SD2 Our last offering is from Emmet J. Duffy: Without using logarithm tables, slide rule, "slide rule calculator," etc., determine which is greater, e^{π} or π^{e}.

Solutions

NS 2 A magnetic dipole $m\overline{I}_z$ is situated at the origin of cylindrical coordinates (r,ϕ,z). A charge of q is situated at (2,0,0). In a situation such as this it is well known that the Poynting vector does not vanish so there is an energy flux $\overline{S} = (1/\mu_0)E \times B$ and a momentum $\overline{P} = \epsilon_0 \overline{E} \times \overline{B}$ even

though the configuration is entirely static (see, for example, Feynman's *Lectures* Volume II, Chapter 27). The problem is to find the total angular momentum of the electromagnetic field about the z axis; that is, find the integral

$$L_z = \int r\bar{l}_\phi \cdot (\epsilon_0 \bar{E} \times \bar{B})\, dV$$

over all space. (Assuming q, m, and ϵ finite and nonzero, then L_z will be finite and not zero).

The following is from I. Volynshchik: The angular momentum is equal to the time integral of the torque about the z-axis when the charge is brought in from infinity. In international units, the vector potential of the dipole is:

$$A_\phi = (\mu_0 m/4\pi) r/(r^n + z^2)^{3/2}$$

Bring the charge q in along the straight line $(r_0, 0, z_0 + t)$, $-\infty < t \leq 0$, to its final position $(r_0, 0, z_0)$. Then

$$dL_z = qr_0\, \partial A_\phi/\partial z\, (dz/dt)\, dt = qr_0\, dA_\phi; \text{ hence}$$
$$L_z = (\mu_0 mq/4\pi) r_0^2/(r_0^2 + z_0^2)^{3/2}.$$

FEB 1 In a four-move chess game, White's moves were: 1. P — KB3; 2. K — B2; 3. K — N3; and 4. K — R4. On the fourth move, Black delivered mate. What were Black's moves?

The solution is:

P — KB3	P — K3
K — B2	Q — B3
K — N3	Q x P ck
K — R4	B — K2 mate

This solution was discovered by Gerald Blum, Randy Kimble, William J. Butler, Jr., and Benjamin W. Wurzburger.

FEB 2 How many sequences can be formed using the 28 dominoes?

My feeling is that this is a very difficult problem as originally intended. However, it was not clear as worded that *legal* (in the domino sense) sequences were required. Without this proviso, Harry Nelson was easily able to supply the following solution:

Each of the two parts of a domino is either blank or has pips of one to six in number. Seven dominoes have identical parts, from double-blank to double-six, and 21 dominoes have dissimilar parts, from blank to six. If the dominoes are placed end to end, they can be arranged to form 28! different ordered sequences. In every sequence, each of the 21 dominoes having a different number of pips in its parts can be oriented in two different ways. Therefore, the total number of sequences is $(2)^{21} \times 28 \approx 6.39397 \times 10^{35}$.

For legal sequences, the best we have is the proposer's (Eric Jamin) sketch of a solution. Basically, the solution is to find how many complete closed routes exist over a heptagon and all its diagonals, this number being equal to the number of different circular arrangements of the dominoes, excluding doubles (label the vertices of the heptagon 0 to 6; edges and diagonals correspond to the 21 nondouble dominoes having digits equal to those on the two vertices joined by this edge or diagonal). This number is equal to 129,976,320; reverse routes considered different. There are 3^7 ways of inserting the seven double dominoes and 28 ways to break the loop to give a sequence; this gives a grand total of 7,959,229,931,520. Responses also from R. Robinson Rowe, Gerald Blum, and William J. Butler, Jr.

FEB 3 The word "FACETIOUS contains all five vowels (no duplicates), and they occur in alphabetical order. Name another English word (no proper nouns) having the same properties.

Jeffrey A. Miller found three words: ABSTEMIOUS, ABSTENTIOUS, and ARSENIOUS; William J. Butler, Jr., added PARECIOUS, and Harvey M. Elentuck and other readers added FACETIOUS. Other respondents included James Finder, Frank R. Smith, Emmet J. Duffy, Morrie Gasser, Randy Kimble, Harry Zaremba, Gerald Blum, R. Robinson Rowe, Arthur J. (illegible), Harold C. Leighton, and the proposer, Mark D. Yellon.

FEB 4 Any system of locks requires a water supply at its upper level. For the Panama Canal, this supply is Gatun Lake. For which vessel transiting the Canal from the Atlantic to the Pacific does more water flow out of Gatun Lake — an aircraft carrier or a rowboat?

All three possible answers were received. I am *not* an expert on canals, so I will present responses from one proponent of each. Considering the current political maneuverings with the Panama Canal, I should probably let Dr. Kissinger adjudicate the result (despite his connections with my old Cambridge rival). Our first position, for equality, is from E. B. Jarman, the proposer:

The answer — the loss of water from Gatun Lake is identical incident to the passage of both vessels. Both the (ascending) lock entering the lake and the (descending) lock leaving the lake must be considered. Raising the water level of the ascending lock to the lake level, after the vessel enters and the entering gate is closed, requires the same amount of Gatun Lake water for both (a volume equal to the mean horizontal area of the lock multiplied by the height the water level is raised). However, when the vessel enters the lake from this lock, an amount of water equal in weight to that of the vessel must flow back into the lock from the lake to maintain the water level. At this stage of transit, Gatun Lake has lost more water in the case of the aircraft carrier. Proceeding southward toward the Pacific, however, as the vessel moves into the descending lock, it displaces again an amount of water equal to its weight, which flows back into the lake to maintain the water level, exactly compensating for that lost from the lake to the ascending lock for the same vessel (and over and above the equal amounts lost to raise the level of the ascending lock in both cases). Therefore the outflow from the water supply of Gatun Lake is insensitive to the size of the vessel transiting via the canal.

Many readers favored the rowboat; the following from Gerald Blum is typical:

To clarify the problem, assume there is one lock on each side of the lake connecting it to each ocean, and assume the locks are of equal size and the oceans of equal elevation. Let V_L be the volume of water needed to raise a lock from ocean height to lake height, and assume the volume of the lake to be much greater than V_L, so that the lake elevation is unaffected by a lock filling. Now consider a complete cycle of ship passage. Let the volume of water displaced by the ship be V_S. The cycle begins with both locks open to the

ocean and closed at the lake end. The ship enters the Atlantic lock, and the ocean door of that lock closes. The lock is filled to lake height, which drains a quantity ($V_L - V_S$) of water from the lake. The lake door of that lock then opens, and the ship sails onto the lake. An additional quantity of water equal to V_S enters the lock from the lake. While the ship is crossing the lake, the Atlantic lock's lake door is closed and the ocean door opened, releasing a quantity V_L of lake water into the Atlantic. Meanwhile, the Pacific lock has closed its ocean door and opened its lake door, sending V_L of water from the lake into the lock. The ship then enters the Pacific lock, and V_S of water returns to the lake. The lake door of the Pacific lock is then closed, the ocean door opened, and the ship sails out into the Pacific as a quantity of lake water equal to ($V_L - V_S$) enters the Pacific. The cycle is complete, and the lake has lost a total quantity of water = $2V_L - V_S$, this is maximal when V_S is minimal, so more is lost for the rowboat.

R. Robinson Rowe seems to have extra information about the Panama Canal that leads him to take the minority position:

In an ordinary lock, the chamber has a dead volume v at its lower stage and a volume (V + v) at its upper stage. A vessel with displacement D, if locking up, enters the chamber at its lower stage "carrying its displacement with it" — that is, as the vessel advances, water flows around it to its wake. So when the lower gate is closed behind it, the volume of water in the chamber is reduced from v to v − D. Then the culvert valves are opened to raise the water level to its upper stage. Then the volume of water in the chamber is (V + v − D). Thus the water added is (V + v − D) − (v − D) = V. That is, it is independent of the displacement and would be the same for a rowboat as for an aircraft carrier. A similar analysis holds for locking down.

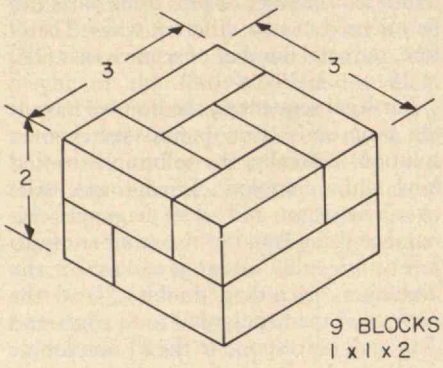
But only one lock in each direction at Panama is an ordinary lock. The other five each way are subdivided with auxiliary gates, so that an aircraft carrier would have to use a full chamber 1,000 feet long, but the row boat would need only a subchamber 600 feet long. The chambers are 110 feet wide, so a passage of an aircraft carrier would use 1000 × 110 × 85 × 2 × 7.48 = 140,000,000 gallons and a rowboat (1000 + 5 × 600)/6000 = two-thirds as much. As a matter of collateral interest, the unsubdivided lock is the Lower Miraflores Lock. Volumes are for mean tide, 85 feet lower than Gatun Lake. About 90 per cent of transiting vessels are less than 600 feet long and use the smaller chambers. A rowboat would probably be locked with a larger vessel, effectively using no water at all. The facts would differ for two-way locks which use the same water to lock one vessel up and another down.

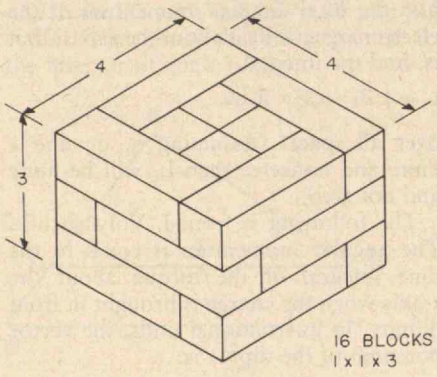
Responses were also received from Jack Parsons, W. A. Schoenfield, James Finder, Bruce Parker, Arthur J. (illegible), Harry Zaremba, and William J. Butler, Jr.

FEB 5 A man is to pack a carton with equal-sized rectangular blocks. To prevent shifting during shipping, there must be no fault in the packing; that is, no plane may cut through the carton without cutting a block. What is the smallest sized carton, in volume, which he can use if the blocks are 1 x 1 x 2? 1 x 1 x 3? 1 x 2 x 3?

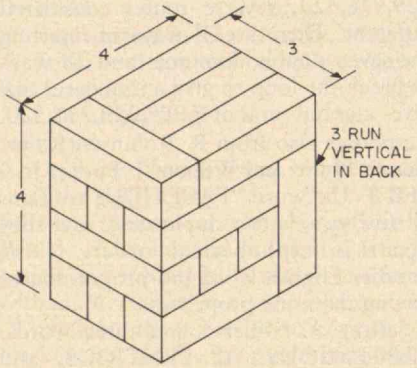
The following self-explanatory pictures are from Robert Pogoff. They are minimal among all responses received. I have not allowed solutions where the carton is not completely filled.

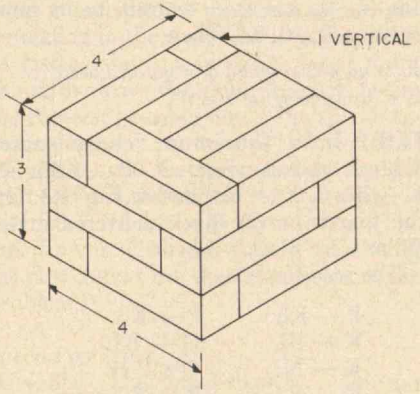
Responses were also received from Gerald Blum, Bruce Parker, Harry Zaremba, Norman M. Wickerstrand, Richard J. Allen, William J. Butler, Jr., and the proposer, Eric B. Jamin.



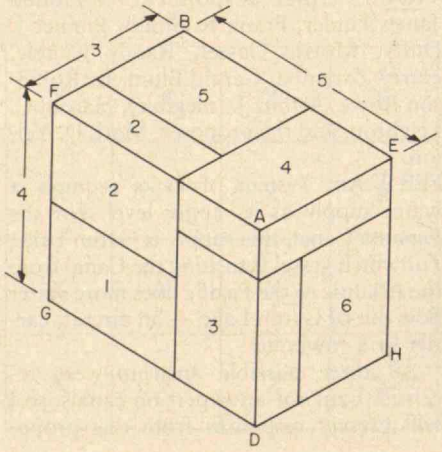


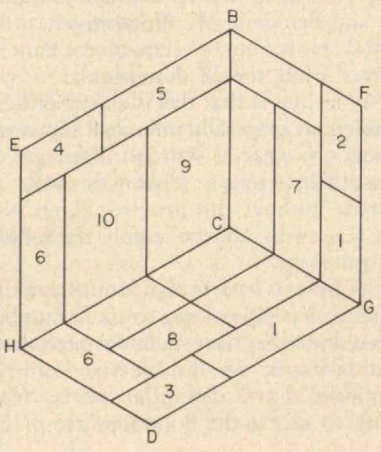
16 Blocks 1x1x3 Two solutions:





10 Blocks 1x2x3 Two solutions:





Better Late Than Never

J/A 4 Emmet J. Duffy has submitted a pair of letters in which he shows the existence of N distinct positive integers such that any (N − 1) sum to a square, for any N, equals 0, 2, 4 (mod 6).

O/N 1 The following analysis is from Emmet J. Duffy:

The correct way to play the hand is given in the answer to **O/N 1**, but some of the odds are not correct. Probability or odds should be based on the cards in the opponents' hands at the time a decision is to be made. Odds based on the opponents' hands at the start of the game will be incorrect if either opponent does not follow suit.

When declarer makes his decision to finesse or play the ♥A, West has six cards and East has seven cards. One way to compute the odds is to determine the

INSIGNIA FAVORITES

THE M.I.T. CHAIR. A traditional favorite made of selected northern hardwoods and finished in satiny black with gold trim and gold M.I.T. crest. In all black or black with cherry arms. each **$75.00**
Red and grey Duraleather Chair Cushion, foam filled. **13.00**

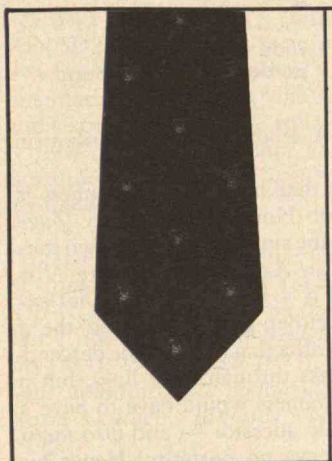
M.I.T. INSIGNIA TIE. A distinctive way to show off the M.I.T. shield. Fine quality polyester with repeat pattern on maroon or navy ground. 4" wide. **6.95**

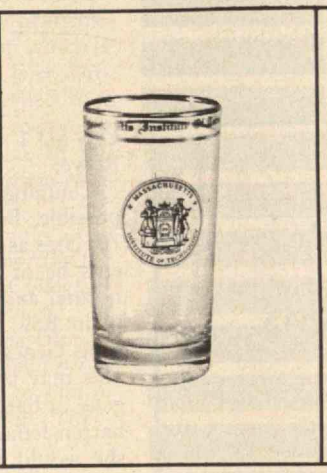
M.I.T. GLASSWARE. Fired-on silver Tech crest with chip-resisting platinum rim. Hi-ball, Double Old Fashioned, Single Old Fashioned. each **2.50**

PERSONALIZED PLAQUE. Cast bronze M.I.T. emblem mounted on solid walnut shield or rectangle.
Plaque and bronze plate **24.95**
Engraving $6.00 extra.

DIRECTOR'S CHAIR. Sturdy folding hardwood frame in natural or black finish. Seat and back in heavy white cotton duck with 3-color M.I.T. seal. **29.95**

DIRECTOR'S CHAIR with walnut frame. **36.90**





TR-1975

the Coop

M.I.T. Student Center
84 Massachusetts Avenue
Cambridge, Mass. 02139

Quan.		TOTAL PRICE
___	M.I.T. Chair, cherry arms	Express Collect 75.00 ___
___	M.I.T. Chair, all black	Express Collect 75.00 ___
___	M.I.T. Chair Cushion	13.00 ___
___	M.I.T. Insignia Tie in navy	6.95 ___
___	M.I.T. Insignia Tie in maroon	6.95 ___
___	Hi-ball Glasses	2.50 ___
___	Single Old Fashioned	2.50 ___
___	Double Old Fashioned	2.50 ___
___	Director's Chair ( ) natural, ( ) black	29.95 ___
___	Director's Chair in walnut	36.90 ___
___	Plaque	24.95 ___
___	Engraving	6.00 ___
	( ) Shield, ( ) Rectangle	

Name to be Engraved _____
Class of _____

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE

Please ship to: _____
Street _____ City _____
State _____ Zip _____
Ordered by: _____
Street _____ City _____
State _____ Zip _____
COOP # _____

☐ CHARGE MY ACCOUNT ☐ OR I ENCLOSE REMITTANCE

Mass. Residents: Add 5% sales tax (except ties).
Out-of-state Residents: No tax except when delivered in Mass.
(Make Checks Payable to the Harvard Cooperative Society)

SHIPPING AND HANDLING IN CONTINENTAL UNITED STATES

		EAST	MID-WEST	WEST
Director's Chair, Glassware and Plaque	(per order)	1.50	2.50	3.50
M.I.T. Chair Cushion	(per order)	.80	1.20	1.50
M.I.T. Insignia Tie	(per order)	.60	.60	.60

M.I.T. Chairs: Shipped Express Collect from Gardner, Mass.
Please allow approximately 4 weeks for delivery.

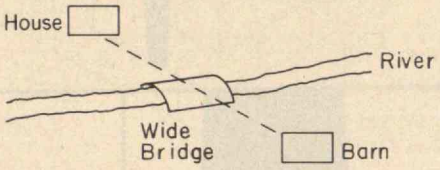
number of different hands West can have, without the heart, compared with the number of hands West can have with the heart. For example, if West started with no spades and dropped three clubs on the three spade leads, the 13 cards are six spades, one heart, and six clubs. West can now hold six clubs for which there is only one combination, or West can hold one heart and five clubs for which there are six combinations. Hence the odds for the finesse are 6:1. If West started with one spade and dropped two clubs on two of the spade leads, the 13 cards are five spades, one heart, and seven clubs. West can hold six clubs for which there are seven combinations, or West can hold one heart and five clubs for which there are 21 combinations. The odds for the finesse are then 3:1. The odds for all possible spade holdings in the West hand can be computed in this manner, but there is a much simpler way to compute the odds. From the six cards in the West hand and the seven cards in the East hand, subtract the number of spades figured to be in each hand. The numbers that remain will give the odds. For example, if West started out with no spades, then East started with nine spades and played three of them on the three spade leads. East now has six spades. Subtracting six from seven leaves East with one card which could be the heart, and West has six cards any one of which could be the heart. Hence the odds that West has the heart are 6:1. The computation is as shown in the table at the top of these two columns. If West and East each play spades on all three spade leads, and there is no knowledge of the spade holdings in either hand, then with six cards in the West hand and seven cards in the East hand, the odds that West has the heart are 6:7 and play of the ♥ A is preferred.

Spades in West hand at start	*Spades in each hand at time of decision*		*Result of subtraction*		*Odds for successful finesse*
	West	*East*	*West*	*East*	
0	0	6	6	1	6 to 1
1	0	5	6	2	3 to 1
2	0	4	6	3	2 to 1
3	0	3	6	4	3 to 2
4	1	2	5	5	1 to 1
5	2	1	4	6	2 to 3
6	3	0	3	7	3 to 7
7	4	0	2	7	2 to 7
8	5	0	1	7	1 to 7
9	6	0	0	7	Impossible

O/N 4 I have received two interesting letters recently on this problem.

Vern Reisenleiter, an ex-navigator, points out that the third solution presented is incorrect. "Distances are distorted in a Lambert Conformal Projection, and track AB is not east-west; it is, approximately, a great circle track."

Peter Welcher attacked the entire problem which ignores the width of the bridge. His sister gives the following solution for a wide bridge:



O/N SD 1 A rebuttal from R. Robinson Rowe:

Claiming that hereditary barrenness is possible, Bob Horvitz in February (*page 70*) cites as the simplest way that two parents be of an Aa genotype, where A = normal and a = barren. He does not explain how either parent acquired the *a* gene. Genes affecting only female descendants may pass through male lines, but a gene of barrenness would have to have a barren female ancestor — and *ipso facto* she would have no posterity! Hence his presumption that Aa genotypes exist is fallacious. Of his "less likely" examples, the first is quite plausible — that there could be a mutation of a gene in one of the parents. But it is plausible only if the mutation occurred to a gene of the mother, and if the still-fertile mother passed the mutant to a daughter, and if the daughter was barren. But then, since the mother was not barren, what the daughter inherited was only the gene of barrenness — *not* hereditary barrenness. It should be noted that barrenness is defined as "absolute inability to conceive" and its etiology is limited, so far as I can find out, to physiology (such as a constricted oviduct), psychology (such as a mental block), or to surgery (such as an hysterectomy). The first might be congenital, but that is not genetic. The mental attitude may stem from parental restraints, but cannot be of genetic origin. And of course surgery is

not inherited. Finally, I note that Mr. Horvitz only claims possibilities, with no citation of facts. Such would not suffice for evidence in the courts of Maine, Idaho, Utah, and Iowa. As to the antiquity of the problem, I note that you heard a variant of it when in high school say *circa* 1960. I first heard it as a variant (naming no states) in 1913 when in Harvard — posed by a law student seated at the same table in Memorial Hall. I predict it will never die in spite of nit-picking.

FEB SD 1 Ralph M. Jones noticed an alternate solution wherein circles B and C are internally tangent to circle A. This gives the result a = 26, b = 9, c = 14.

The following have responded to the problems indicated:

O/N 4 Abraham Schwartz and N. Sacid Ozker.

DEC 1, 2, and 3 Eric Jamin.

JAN 1 Richard I. Hess, Bill Blake, and Eric Jamin.

JAN 2 Eric Jamin.

JAN 3 Eric Jamin, Richard I. Hess, Bob Lutton, Gerald Blum, Art Hovey, Vern Reisenleiter, and William J. Butler.

JAN 4 Gerald Blum, Bob Lutton, Ray Sullivan, Stanley Joehlin, Aviva Eichler, William Proctor, and Michael Auerbach.

Proposers' Solutions to Speed Problems

JUN SD1 By the law "down under," peacocks don't lay eggs — only peahens.

JUN SD2 Let $x^{\pi e/x}$ be a function which is e^{π} when x is e and π^e when x is π. Differentiating the function with respect to x and setting the derivative equal to zero, it is seen that the maximum value of the function occurs when x is e; hence e^{π} is greater than π^e.

Professor Allan J. Gottlieb is Coordinator of Computer Activities at York College of C.U.N.Y.; he studied mathematics at M.I.T. (S.B. 1967) and Brandeis University (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at York College, Jamaica, New York, 11451.

Letters

Continued from p. 3

hissing sounds often reported. With the gas released, the unstable, writhing mat mass sinks into the Loch, perhaps to be sighted again or photographed on its journey downward by the crew of a scientific submarine.

The lake bottom area is so large that the chance of this phenomenon being created and sighted fairly often is very good.

Eat your heart out, Loch Ness monster!

Robert G. Hahl
Alexandria, Va.

Mr. Hahl is a physical scientist for the U.S. Department of Defense.

Books

Continued from p. 10

rial quality that cannot now be duplicated. Many old neighborhoods of no historic significance have irreplaceable uses and meanings for their residents. We have built our urban house; now we must inhabit it, repair it, and adapt it to our changing needs.

Good Housekeeping

In a sense, the architecture that is becoming increasingly required — the smaller scale fix-it-up, re-use it, find out specifically what we need to change and do it architecture — is akin to the experience of someone who deals with domestic problems daily. Doris Cole's book shows us that this architecture is historically the sort practiced by American women.

The early work women have done in designing and building tipis, houses, furniture, storage space, and mechanical equipment has been of a very personal, domestic, and non-pompous character. That, of course, is precisely what is lacking in much of our manmade surroundings today. Any modern skyscraper architect can look at the work of the Beecher sisters and see a faithful attention to human needs well worth copying.

Whether women architects are intrinsically different or better than men architects is not the issue; whatever our sex, we all face a poor economy, the demands of environmental conservation, and questioning within the profession. I am not saying that women are better able to face today's architectural problems because they are women. I am saying that the particular conditioning of women in society will be valuable.

Many women are taught to deal with people's problems very specifically, rather than in the abstract. They have been trained to conserve and re-use, and to solve problems in an atmosphere of direct feedback. Our society has encouraged women's sensitivity to its domestic needs. Most of our architects, unfortunately, lack this sensitivity. Doris Cole puts some of the blame for unresponsive architecture on the pyramidal office structure that pervades the profession. She thinks these large concerns are not comprehensive enough; that one man designing enormous projects through descending layers of minions cannot be fully responsive to either his clients or his staff. In support of her argument, I can say that the most monotonous, unpleasant, and uncomfortable buildings I know were designed in this manner.

Doris Cole gives us many examples of women's work in design, and most of them can be characterized as decentralized, nonpyramidal design: a heritage that seems particularly appropriate in the

war against urban anonymity. However, now that women might make especially useful contributions to architecture, Ms. Cole documents a decline in their registration and participation. In pioneer days, American women designed and built houses as a matter of domestic necessity. As the new country developed, woman's service was depended upon less and less, until she was expected only to decorate her own home, and then to stay home and be a decoration in it.

From Tipi to Skyscraper comes at a good time. As we face the prospect of homesteading in concrete pigeonholes, she brings examples of humane design. That the designers were women is a bonus fact from which we women can derive encouragement, confidence, and pride. Ms. Cole exposes and honors our down-to-earth roots, a dignification that has been long overdue.

Margaret Hickey is a practicing designer for Bernard Soep Associates, Inc., and Visiting Lecturer in Architectural Technology at Massachusetts College of Art. She is an alumna of M.I.T.

Mind and Machine

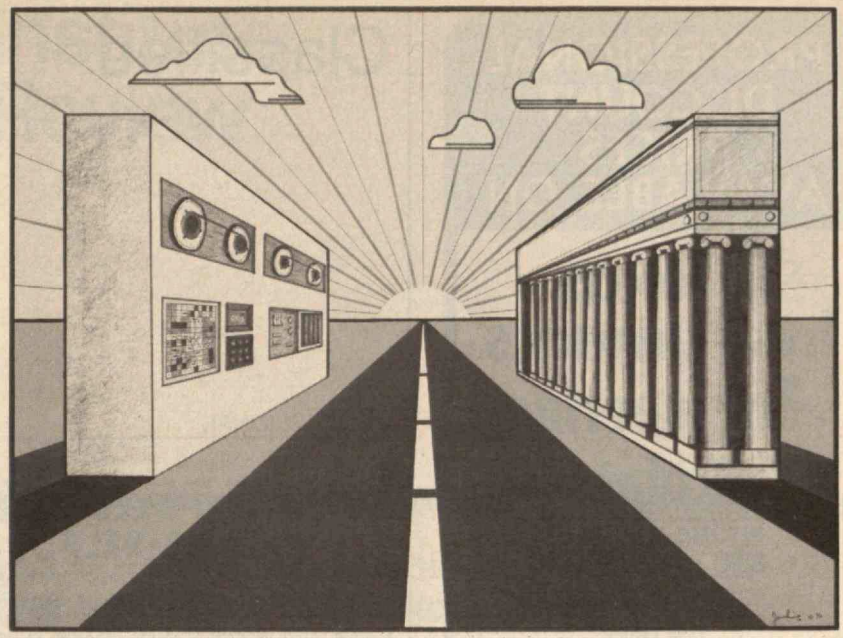
Computers and the Learning Process in Higher Education
J. F. Rockart and M. S. Scott Morton
New York: McGraw-Hill Book Co., 1975; xxii + 356 pp.; $17.50

Reviewed by R. C. Butman

It must be a universal truth that if a new technology can be exploited for fame, fortune, fun, or perhaps even for the benefit of mankind, someone will do it. A shining example of the exploitation of new technology is the computer, whose technical growth and increasing popularity have been truly awesome. Yet, to the dismay of many, Computer Assisted Instruction (CAI) has languished in the midst of mushrooming computer use in other areas, and despite substantial industrial investment and years of generous federal funding. Now the industry has faded away, its ventures financial disasters, and government funding has dried up.

As the years pass, prophets insist that there is a place for CAI if the cost of computer storage drops by a factor of ten, if communications network costs drop, and if courseware development costs are low and/or can be spread over a large student population.

Now Drs. Rockart and Morton in *Computers and the Learning Process in Higher Education* explore yet another "if." If technology and the learning process can be made to correspond more closely, then the use of technology for teaching in higher education will come into its own.



Toward a Taxonomy of Learning

In this study, one of many conducted for the Carnegie Commission on Higher Education, the authors turn first to established learning theory for a model or taxonomy which might inform choice of the machine best suited to the instructional task at hand. Finding little comfort in classic formulations, they proceed to develop their own model of the learning process. They then score various learning mechanisms (lectures, books, CAI, etc.) according to ease of use, cost, and flexibility when those mechanisms are used to aid students in acquiring and using skills, facts, and concepts.

The authors conclude that CAI does not score well on cost-effectiveness and adaptability in conventional learning situations, and so it cannot be expected to supplement traditional methods — notably lectures and classroom discussion — for many years. CAI scores highest as a support mechanism for drill and practice, for the integration of new skills and concepts into the individual's existing knowledge, and for testing.

But the reader is left with no certainty that CAI scores high enough to invite its widespread adoption, and his uncertainty is reinforced by the warning that each case must be considered individually. Further, the authors predict that, for the most part, CAI will be a supplement to currently used learning mechanisms, with the obvious implication that cost per student hour will increase — an unhappy prospect in today's and tomorrow's economy. A recognition of the animosity of the typical university faculty member toward a machine replacement adds yet another discouraging touch. All in all, the book's conclusions sound a feeble trumpet for the CAI era.

Disappearing Market

Drs. Rockart and Morton suffer a common difficulty in trying to generalize about a computer application — higher education — which nearly everyone agrees is not subject to generalization. The authors themselves caution against generalization. One must conclude they have attempted an impossible task.

Given no substantial cost changes in conventional education or courseware production costs, I doubt CAI will ever gain a significant foothold until some group undertakes a hardheaded market survey which is explicit in its evaluation of CAI benefits, and of the effectiveness of specific CAI systems vis-à-vis conventional education and training. Too much general discussion of CAI's universality has taken the place of specific studies of applications in specialized areas where computers might be worth the cost.

A superficial view of CAI use may lead one to presume that courses having large enrollment would be prime candidates for conversion to CAI. Yet too often those courses are, per student hour, among the cheapest, so cost comparisons with CAI may in fact be unfavorable. There is no question that a large student population is required if course development costs are to be amortized. So large, in fact, that one must look to the possibility of aggregating the required population on a regional or national basis, rather than on a single campus.

It is in some ways unfortunate that CAI must be considered first as a device for lowering costs. The history of CAI programs fading away as government support is withdrawn suggests strongly that local school systems do not find CAI's benefits worth the expense. The proponents of CAI must take economic realities into account.

Robert C. Butman is a member of the Processor and Education Technology Group of M.I.T.'s Lincoln Laboratory and serves on the Concord, Mass., School Board.

Classified

PROFESSIONAL

VACATIONS

PUBLICATIONS

FOR SALE

Classified Ads: $3.00 per line; two-line minimum. (Allow 32 letters & spaces for first line; 50 letters & spaces for each additional line.)

Display Ads: $25.00 for first column inch; $20.00 for each additional inch.

Copy Deadline: one month prior to publication date. Payment in advance of insertion required for less than three insertions in one year. Send orders to Classified Section, *Technology Review,* M.I.T., E19-430, Cambridge, Mass. 02139.

Institute Review

In This Section

$4.6 Million in Scholarships to Be Given Next Year as "Equity" Rises to $2,300; Aid to 2,000 Students

The average undergraduate's budget for next year (1976-77) at M.I.T. — not including travel — will be $7,350. The "equity level" — the amount of self-help which needy students must undertake in the form of loans and jobs before scholarship assistance is available — will be $2,300.

If Student Financial Aid Office estimates are correct, 2,050 undergraduates will need financial help to meet their expenses in 1976-77, and their average need will be $4,400. Undergraduates will earn and borrow $4.4 million to help meet their tuition and living expenses, and there will be scholarship grants of $4.6 million.

Available funds designated for scholarships — the income on scholarship endowment, non-M.I.T. scholarship funds, and gifts — will total $3.6 million in 1976-77. To meet the commitment for scholarships to needy undergraduates next year, therefore, some $1 million will be required from unrestricted funds of the Institute.

During the current (1975-76) year, when 1,880 needy undergraduates had an average need of $4,150 and the equity level was pegged at $2,100, nearly $800,000 was required from unrestricted funds.

This increasing gap between scholarship needs and the funds designated to meet them — that is, the growing dependence on unrestricted funds for scholarships — is a subject of serious concern, says President Jerome B. Wiesner; $10 million of endowment for new fellowships, scholarships and loans is "a vital part of the M.I.T. Leadership Campaign," he says.

Aid Assured for All Admitted

For the past ten years financial aid — self-help (loans and jobs) and scholarships — in the full amount of his or her need has been assured to each admitted undergraduate whose family and personal resources fell short of meeting the average undergraduate budget. Financial aid programs were founded in two policies:

— All financial aid is offered solely on the basis of demonstrated need; no special scholarships are available to honor high performance, measured by whatever criteria — academic, extracurricular, or athletic.

— Admissions decisions are made without respect to financial resources and potential financial need; this sharp separation between admissions and financial aid procedures is "a principal way of ensuring a student body of continued high caliber," thinks Jack H. Frailey, '44, Director of Student Financial Aid.

During this ten-year period the need for financial aid by M.I.T. students has grown steadily with the growing cost of an M.I.T. education. The profile of family incomes represented in the student body has maintained a constant relationship to U.S. family income; the fraction of undergraduates who need some form of financial aid has remained reasonably constant, too.

What has failed to keep pace with the rising cost of attending M.I.T. is the endowment to support scholarships. The result is the necessity to use unrestricted funds for scholarship grants and to limit the total of scholarship awards. The equity level is now higher at M.I.T. than at any other school with which the Institute shares a significant number of common applicants. For example, this year, when M.I.T.'s equity level is $2,100, the self-help expectation at Yale and Princeton is $1,900, at Harvard $1,600. A needy student choosing M.I.T. over any of these schools in 1975-76 was thus committing himself to significantly more term-time work and debt, because he would receive less scholarship help.

The purpose of the Leadership Campaign's $10-million financial aid goal is twofold: to eliminate the dependence on unrestricted funds for scholarships, and to decrease M.I.T.'s equity level so that applicants will be able to more fully dismiss short-term financial considerations from

their criteria in choosing which school to attend. Career interests and educational objectives will then be given their proper, primary role in the decision, says President Wiesner. □

Jobs as a $1.8 Million Part of Student Aid

The "self-help" part of M.I.T.'s student aid "package" (*see above*) includes both loans and job earnings — a total of $1.8 million to be earned by "needy" undergraduates in the year just ending, typically $800 or $1,000 to be earned by each student in part-time work during the term and nearly that much again in full-time work in the summer.

But no one is "assigned" a job, and no one "protects" jobs for "needy" students. "We'll show you how to go about it, but you have to do it," says Lawrence E. Maguire, Director of Student Employment, to a new class of freshmen every fall.

Mr. Maguire helps with sample resumés, lists of suggestions, lots of advice on where to look and how to understand and capitalize on students' assets, and a student staff ready with plenty of advice of their own.

But the primary resource is the students' initiative, aided by the Student Employment Office itself — one big bulletin board, covering three walls, with jobs available and jobs wanted posted in different categories everywhere. Perhaps 20,000 people will have crossed the threshold of Room 5-122 in the year ending on June 30; over 10,000 questions will have been asked — and answered.

Undergraduate students of M.I.T. will have earned $3 to $4 million in the year; that's up about $1.3 million over 1974-75.

Term-Time Jobs: Plenty and Varied

Almost every "needy" student commits himself/herself to part-time work during the term, an average of ten to 12 hours a week at pay ranging from $2.30 to over $3.00 (average about $2.75) per hour. The Institute itself is by far the largest employer, and the typical term-time job — especially for a freshman — is in dormitory, dining hall, or library. Perhaps 10 to 15 per cent of term-time earnings are from such jobs; but administrative and clerical work is available in many offices, and the lucky minority — a big one — take laboratory jobs which give both technical experience and the money needed to help pay M.I.T. expenses.

Mr. Maguire thinks the total of on-campus jobs available during the term is fewer than the number of students seeking them by a 3-to-2 margin; half the work force is made up of students who do not have student aid contracts to fulfill; it's regarded as good experience.

But students who commit themselves to as much as 12 hours a week have to forego activities. "I like my job," said one girl who came into the Student Employment Office as this story was being researched, "but if I had my choice I'd go to a seminar once in a while."

"Start Early, Ask Everyone, and Pray"

The same 3-to-2 ratio of jobs to job-seekers exists in the summer, when more students come into the job market for full-time work and when more of them welcome off-campus assignments.

Returning as sophomores last fall, members of the Class of 1978 gave uniform and emphatic advice to their successors seeking future summer jobs: "start early, ask everyone, have friends in high places, pray, and don't live in Detroit." Almost half the sophomores felt they had a "very difficult" or "moderately difficult" job search.

By Mr. Maguire's analysis, nearly two-thirds took nontechnical jobs — gardening, painting, clerking, carrying mail. Of the remaining third, 25 per cent had work that was "professional or managerial" in nature, half had "skilled or semi-skilled" jobs. By sophomore and junior summers a far larger proportion of M.I.T. undergraduates would be reported in the "professional" and "skilled" categories.

Median earnings in the summer between freshman and sophomore years in 1975 were $1,000 to $1,250. Women had more trouble than men finding summer jobs, they were overrepresented in the unskilled and clerical ranks, and the median of their earnings was between $750 and $1,000. □

$30 Million for Scholarship Endowment

One of the first endowed scholarships at M.I.T. was made possible by a modest Bostonian named Richard Perkins. In his annual report for 1887, President Francis A. Walker recalled that Mr. Perkins, "before he became a confirmed invalid, found great pleasure in visiting the buildings of the Institute and, without making himself known, observing the students in their drawing rooms and laboratories." Mr. Perkins' will provided $100,000 for M.I.T., half for the Richard Perkins Scholarship Fund which is still listed in the General Catalog.

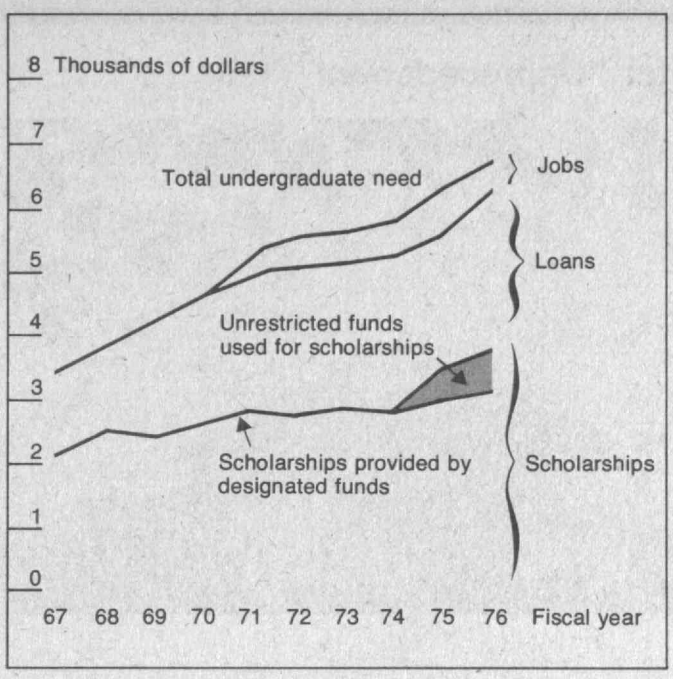
Nearly a century later came the largest single gift for scholarships — a grant of $1.2 million from Mr. and Mrs. Eugene McDermott, which added a full 10 per cent to the scholarship endowment of the Institute. In 1960-61, its first full year of operation, the Eugene and Margaret McDermott Scholarship Fund produced $61,000 in expendable income. By 1975-76 that figure was up to $131,566. In the years since the McDermott Fund was established, it has made possible scholarship grants of $1,419,635 to over 300 McDermott Scholars.

M.I.T.'s total of scholarship endowment in funds such as these is now $21 million.

Junior in M.E. or Chem. E. to work in R & D laboratory testing centrifuges for large-scale centrifuge manufacturer; do testing and R & D work.

Electrical engineering student junior or senior to assist senior engineers in circuit design. Should be familiar with both analog and digital design.

These two summer jobs, advertised in April on the bulletin boards in the Student Employment Office, are long gone. More like them — and semi-skilled and semi-professional as well — are needed, says Lawrence E. Maguire, Director of the Office. M.I.T. financial aid policies encourage students to seek summer earnings to supplement loan and scholarship grants, and summer jobs are always in short supply.



It was in 1966 that M.I.T. first pledged to meet the demonstrated financial need of all successful applicants for undergraduate study. Accordingly, the Institute provided just under $3.5 million in loans and scholarships for undergraduates in 1966-67; in 1971 loan funds proved inadequate, and term-time jobs were redefined as an additional resource in distributing aid. In each of the years since scholarship funds fell short of the need, and unrestricted funds of the Institute were added to make possible scholarships for all students whose need exceeded the self-help level. The demand for unrestricted funds will exceed $1 million in 1976-77, and the shortfall of income from scholarship endowment is predicted to grow rapidly during the rest of the decade if new endowment support is not available.

Financial Aid at M.I.T.: An Example of How It Works

Consider a fictional John or Mary Doe, applicant to enter M.I.T. with the Class of 1980 next fall. Here is how financial need will be established and M.I.T.'s financial aid offer determined:

To measure their ability to pay for an M.I.T. education, the Doe family completes a Parents' Confidential Statement supplied and processed by the College Scholarship Service, a subsidiary of the College Entrance Examination Board. This form covers data not only about current income but about other assets, unusual expenses and financial commitments, the number of college-age children, and the number of other dependents.

The Student Financial Aid office applies the College Scholarship Service's need analysis system to the information supplied by the Service and establishes the dollar amount expected as the Does' contribution to the cost of John's or Mary's year at the Institute.

The costs of the year at the Institute are standardized in an "annual student budget," which for 1976-77 will be:

Tuition	$4,000
Medical fee	160
Room and board	2,420
Books and materials	220
Personal expenses	550
Total	$7,350

A variable increment is added for travel, the amount depending on the distance to the student's home.

A student's "need" is defined as the difference between this annual budget and the amount of the family's expected contributions.

Assume, for example, that analysis for the Doe family circumstances reported to the College Scholarship Service leads M.I.T. to expect a contribution of $2,250 toward John's or Mary's education at M.I.T. The student's remaining need will be $5,100. When John or Mary is admitted to the Institute, he or she is assured of an "aid package" which meets that total need.

This "aid package" will consist of a fixed increment — the same for essentially all "needy" students — of "self-help" (loan and job), with the remaining amount as scholarship aid. For 1976-77, this "self-help" commitment by essentially all "needy" undergraduates will be $2,300. Most students expect to earn between $800 and $1,000 a year from part-time work, which is usually available in dining halls, dormitories, offices, and libraries, and — especially for upperclass students — laboratories; they take the balance of the "self-help" increment as a loan. The interest rate on that loan will most likely be 3 per cent; the principal can be repaid in equal installments beginning nine months after graduation and extending over ten years.

This loan and job portion of the "aid package" is described as "self-help" because, although it is made available by M.I.T., the costs are ultimately paid by the student.

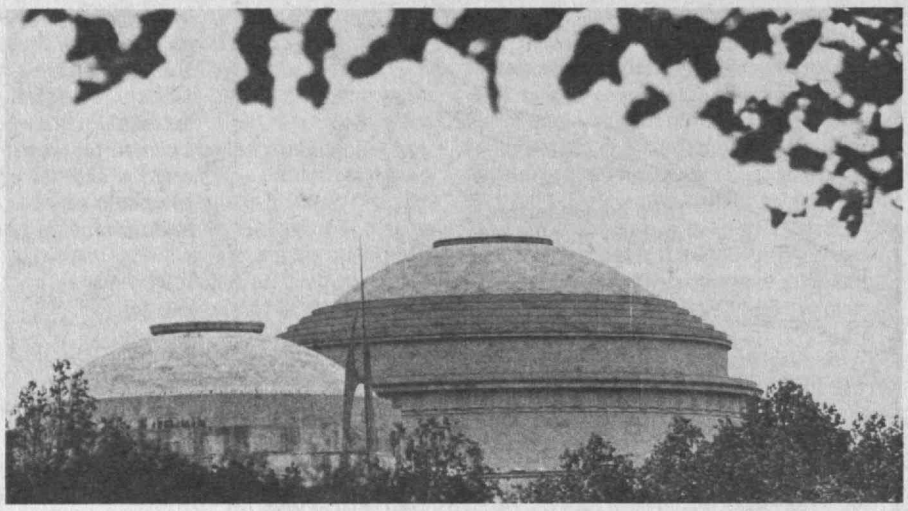
Assume John or Mary plans to earn $800 in the freshman year; that represents a commitment of about 12 hours a week. He or she will then borrow the balance of the "self-help" requirement from the National Direct Student Loans Program or under similar terms from the Technology Loan Fund. The situation is then as follows:

Total budget for the year at M.I.T.		$7,350
Parents' contribution		2,250
Net needed by John or Mary		$5,100
Term-time job earnings	$ 800	
Loan	1,500	
		2,300
Remaining need		$2,800

It is this remaining need which will be met by a grant paid to John or Mary upon enrollment at M.I.T. in September.

In 1976-77 some 2,050 M.I.T. undergraduates (out of a total estimated enrollment of 4,500) will be eligible — like John or Mary — for financial aid. The average "need" to be met by scholarships and self-help will be $4,400, and an average of $3,000 will be contributed by parents and the students themselves (through contributions from their own savings and summer earnings.)

Leadership Campaign at $75 Million After "Unprecedented" Year



What is President Jerome B. Wiesner's vision for M.I.T.?

". . . the pinnacle of excellence," he told 250 members of the Alumni Advisory Council in April. "A place that is a beacon where rationality is respected, where quality is the basic criterion by which we judge what we do.

"M.I.T. is unique among American universities," Dr. Wiesner said, "in the cohesion of its faculty" and in its embracing of "the essential ingredients of a modern technological society" — including not only science, engineering, and architecture but the social sciences — economics, political science, and management — through which technological achievement is mobilized for service to mankind.

It was the first anniversary of the announcement before the same alumni group of the $225 million Leadership Campaign, and President Wiesner and Howard W. Johnson, Chairman of the Corporation, made an optimistic progress report: gifts to the Leadership Campaign stand at $75 million, one-third of the five-year goal.

When it was announced in April, 1975, the Leadership Campaign already stood at $43 million. In the 12 months since then, Campaign giving has been over $30 million — a flow of gifts and pledges unprecedented in M.I.T.'s recent history, said Mr. Johnson.

The $225 million goal remains a tough one, said Mr. Johnson, but he insisted it is "do-able." Success will depend on mobilizing talent and interest in the next 12 to 18 months; they are "the most critical of the five-year Campaign schedule," Mr. Johnson said.

Alumni Fund: Go Up and Stay Up

The Leadership Campaign has two goals:

— To bring M.I.T. a massive, five-year infusion of new resources, most of which will be designated as endowment for general purposes, faculty salaries, and student aid. "Expanding the base of our endowment," Mr. Johnson told the alumni, "is the single most important criterion for M.I.T.'s future strength."

— To raise the level of M.I.T.'s continuing support after the five-year Leadership Campaign period — a question of instilling in many more alumni and friends of M.I.T. the habit of annual giving at new high levels.

Alumni Fund participation in the Leadership Campaign emphasizes the second of these two goals. "A realistic look into the future," wrote Dr. Wiesner and Mr. Johnson in a special letter to all alumni this spring, "discloses one cold fact: the Alumni Fund must double its income by 1980 if the Institute is to maintain its leadership momentum." Toward this end, the Fund has set a goal of $26 million during the five-year Campaign period; it is "an integral component of the Campaign and the vehicle through which most alumni will participate in it," wrote Dr. Wiesner and Mr. Johnson.

"The extraordinary success of the Fund over the past 15 years gives us confidence that these objectives will be reached."

Technology Alone Is Not Enough

Dr. Wiesner's emphasis on management and the social sciences as essential partners with science and engineering in M.I.T.'s future contributions prompted a question from a member of the Alumni Advisory Council in April: The "free market economy" is at the heart of this nation's philosophy and its future needs. Isn't our central problem how to make our system work better "without more management and control?"

A true dilemma, replied President Wiesner, which confronts M.I.T. and indeed the nation: how to manage a complex society and still assure freedoms for its members? How to allow for individuality in a system whose sectors and industries are growing ever more interdependent?

For example, energy. "Clearly our present position calls for more planning," said Dr. Wiesner, just as our present situation would be simpler if better planning had occurred in the past. The crucial question — appropriate to both engineers and social scientists, thinks Dr. Wiesner — is how to deal with problems of such scale and complexity within the American system, without "monolithic" government intervention.

And if that question seems hard to answer today, it will be even harder tomorrow when technology will necessarily be more complex and larger in scale than today's, thinks Dr. Wiesner.

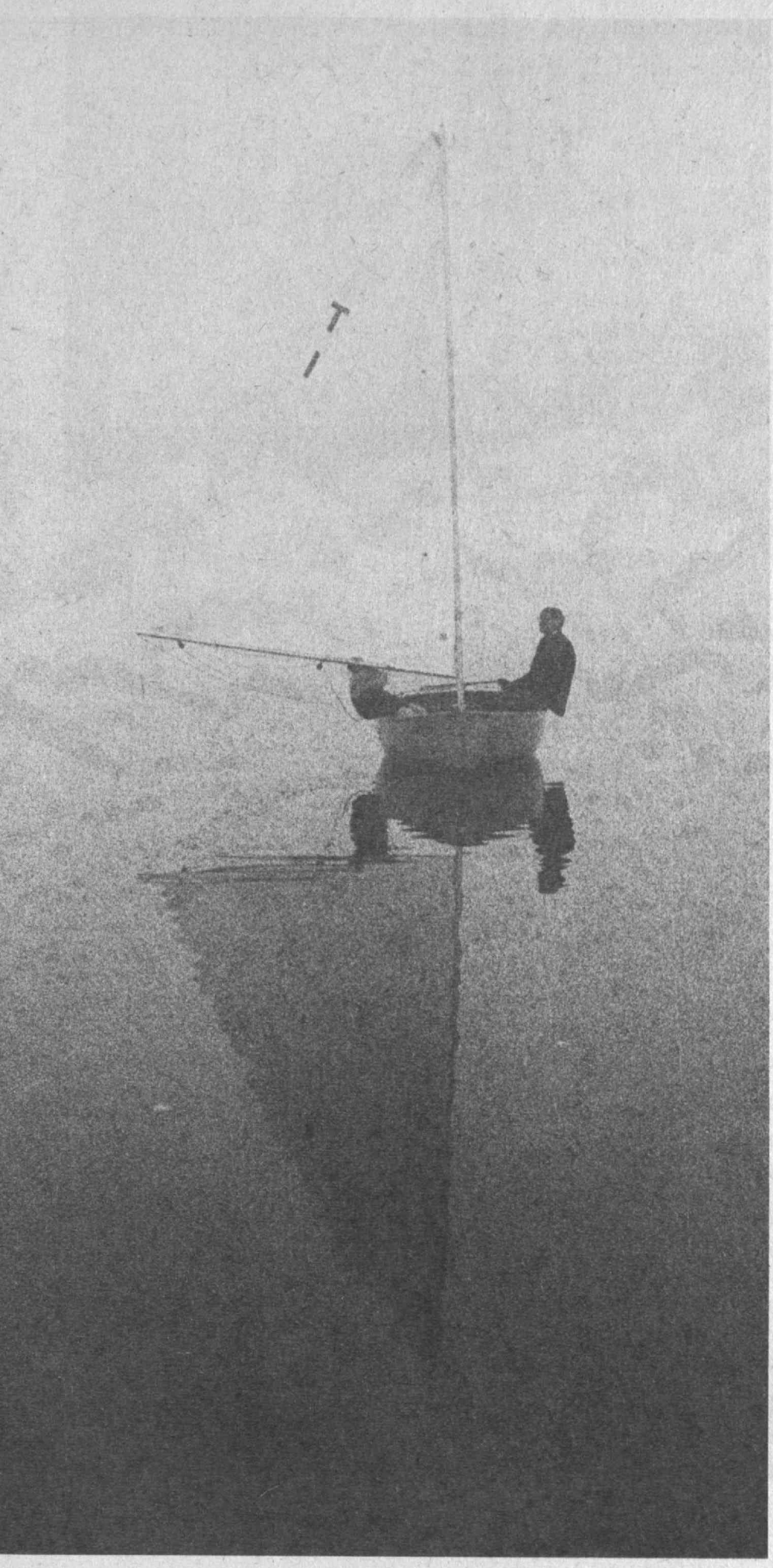
Hence the Leadership Campaign: to give M.I.T. resources so that its faculty can study and teach what they think most important, so that the Institute has freedom "to set the course of engineering, not to follow it. . . . We are firmly convinced that challenging scientific and technological questions are at the root of many problems," Dr. Wiesner told the Alumni Advisory Council. "We remain highly dependent on understanding both complex scientific questions and interdependent societal systems to work effectively on today's and tomorrow's problems." □

Total Giving Down, M.I.T. Moves Up

Total giving to U.S. colleges and universities in 1974-75 was down 3.6 per cent from the previous year, according to the annual survey of the Council for Financial Aid to Education, Inc. But M.I.T. moved up in total voluntary support from the 12th U.S. university (1973-74) to the tenth-place spot in 1974-75.

C.F.A.E. tied the decline in college and university giving to the economic recession of 1973-75. A similar decline coincided with the 1957-58 recession; in both cases, declining stock market prices seem to have been the villains.

As usual, Harvard reported the highest total of voluntary support among American universities — over $52 million. Next came Stanford, $45 million, and the University of California system, $40 million. M.I.T., tenth in the list, had total gifts of $21.7 million.



Faster, Drier Dinghies from the Sailing Fund

The Charles River, sprinkled with sails catching the midday spring easterlies and the soft southwesterlies of dusk, is as picturesque as ever in 1976. But under the triangular sails from the M.I.T. sailing pavilion, everything is very different. For beginning this fall those sails will be worn by the brand-new third generation of the famous "Tech Dinghy."

Twenty-six of the new boats are now on the river, the first fruits of a $270,000 Alumni Fund project to refurbish sailing at M.I.T. When George Warren Smith, '26, Chairman of the fund raising committee, started the project in 1973 his goal was $212,000. Gifts and pledges now exceed that amount, but inflation has taken its toll, and the committee is determined to finish the job.

In addition to the new dinghy fleet, the project will result in a new sailing pavilion, to be named in honor of Walter C. "Jack" Wood, '17, M.I.T.'s first Sailing Master under whose guidance the Institute's sailing program became a model for those at many other American universities. Its Commodore's Room will be named for Olin J. Stephens II, '30, designer of five America's Cup winners.

The original Tech Dinghy was designed by George Owen, '94, Professor of Naval Architecture, when "Jack" Wood first came to M.I.T. A fiberglass replica — the second generation — was launched in 1953 and has been the standard for both men's and women's sailing since then.

Today's third-generation dinghy is a modification of the prototype by Halsey C. Herreshoff, '60, in whose grandfather's Herreshoff Boatyards (Bristol, R.I.) the original Tech Dinghies were built. The new boat is drier and faster — 75 pounds lighter than the second-generation fiberglass model, with higher bow and sides; the builder is Olaf Harken of Vanguard Sailboat Co., Peewaukee, Wisc., builders of the racing boats to be used in the 1976 Summer Olympics. □

Only an experienced eye can tell that this Tech Dinghy is different from its predecessors — higher bow and sides, lighter in weight. But those differences mark the third generation of this famous design, and 26 of the new boats will be used this fall at the M.I.T. Sailing Pavilion. Their construction is one result of a $270,000 fund-raising campaign led for the Alumni Fund by George Warren Smith, '26, to refurbish both boats and sailing pavilion. Gifts and pledges now exceed $212,000. (Photo: Frederick G. Lehmann, '51; opposite page: Richard F. Reihl, '78)

"Deterrents to Change"

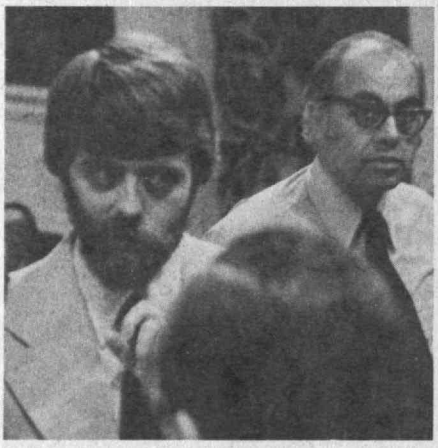
Has the U.S. lost its initiative in technological innovation and economic development?

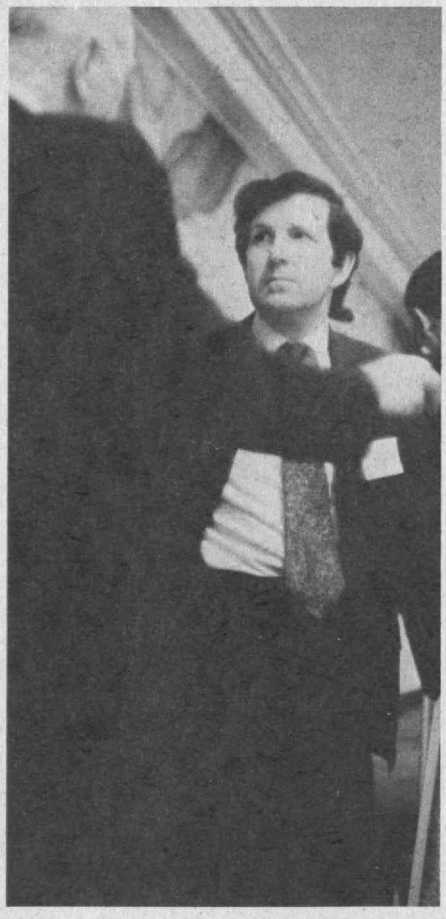
For two days this spring experts from M.I.T. and nine other U.S. firms and institutions tried to answer that question at a regional conference of the Alumni Association sponsored in Washington by the M.I.T. Club of Washington, D.C.

There was no unanimous judgment. President Jerome B. Wiesner said his answer to the question was, "No, not yet." But he warned that the usual criteria for judging productivity and innovation may disguise the true situation. There is no lack of opportunity, he said: "I see an urgent need for continued innovation not only to improve the quality of life and to continue economic development but — even more important — to keep the system working, to retain what has been achieved, to insure that the quality of life doesn't deteriorate drastically . . ."

But there are "ever-increasing deterrents to creative change," said Dr. Wiesner, and he fears these "constitute a social overhead which the nation cannot afford."

Other speakers explored details of the data on which productivity and innovation are usually measured and reached more disparate conclusions which will be reported in detail in *Technology Review* for July/August. □





Among principals at the M.I.T. Club of Washington conference on innovation and productivity: top — *President Jerome B. Wiesner (left), Elliot L. Richardson, Secretary of Commerce, and Edward O. Vetter, '42, former Executive Vice President of Texas Instruments, Inc. (right);* right— *Professor Christopher T. Hill of Washington University;* far right: *Professor Robert G. Gilpin, Jr., of Princeton University;* below: *Nicholas A. Ashford of the M.I.T. Center for Policy Alternatives.*

John Crocker, Jr., on Education: Science Alone is Not Enough

What does life mean? What's worth dying for (if anything)? What can I believe in that's permanent? What, if anything, makes sense out of unmitigated tragedy? Why shouldn't I commit suicide? What makes life worth living?

Education must try to deal with these questions, says John Crocker, Jr., M.I.T.'s Episcopal Chaplain. As Chairman of the Steering Committee for the Seminar on Technology and Culture (a program of interdisciplinary seminars for faculty and students) he works to provide a forum in which these kinds of questions, among others, can be asked. In an interview, he elaborated:

Many people at M.I.T. seem to believe that only what can be shown or found via the scientific method is real and true — and everything else is secondary and subservient to those realities. This is a point of view that suggests that artists are nothing but decorators, musicians nothing but entertainers, and religion nothing but superstition. It assumes that the scientific way of knowing is the only way that leads to *reality*.

But this is a massive rejection of direct experience. When Carlton Fisk hits a home run for the Boston Red Sox in the ninth inning of a crucial World Series game, he experiences a great deal more than science can ever tell him. In most situations, so do we all! And trying to reduce that experience to scientific explanation sacrifices almost everything in it which is humanly alive.

The usual academic anthropology assumes that humans are a mixture simply of body and mind. But I come from a tradition which says that we are a threefold combination of mind, body, and *self*, or spirit. The self-conscious person knows him or herself not only to have a body and a mind, but also to be free and responsible. Mind is the servant, not the master, of the self. The real issue for us is a moral one: what kind of self are we dealing with? What are the motives or purposes of the self? (Brilliantly trained minds have been known to serve Dr. Strangelove.) And the self operates in the realm of personal choice and personal responsibility which is in principle beyond the reach of science.

Science education alone doesn't help the self learn how to live, what to believe in, or what commitments are. But an education which seriously raises these questions may be a real threat to science and engineering education. If a student becomes personally excited about Dostoevsky's *Crime and Punishment,* or moved by the paintings of Cézanne, or awakened to the power and meaning of a religious tradition; that is, if the student starts to mature and seriously ponder the meaning of live, he or she may be diverted from science or engineering for some time.

Science Is Not the Source of Ethics

The Technology and Culture Seminars question the adequacy of science as the only way of knowing all of reality. We ask what people believe about themselves and the world. And we suggest that science is not the source of our ethics. We choose topics that lie at the intersection of the technical/scientific and the non-technical human, political, and ethical questions. This year, our "humanitas" lecture series has been an attempt to look at the western tradition as an evolving perspective. Through that program we intended to say and demonstrate that science is *one* of the products of the western tradition, but only one. There are also profound religious, artistic, literary, and philosophical elements in our tradition; and when these are denied or their importance reduced by the scientific perspective, then our tradition is distorted, and science becomes falsely imperialistic. In fact, as we all know, the real problems in our culture demand far broader perspective for study than any one department in our universities can provide. We try to create occasions on which aspects (including the ethical aspect) of a broader perspective can be heard.

You and I as human beings can't be explained through biology as "organisms in an environment." We are not determined by our environments; we are self-conscious human beings who can *choose* how we will relate to them. A person's *internal* environment — memory, hopes, and choices, not at all programmed by instinct — therefore, is even more important than the external environment. No one has an adequate explanation of how human beings evolved from lower primate life. The fact that human beings cannot exist without language, and that language cannot exist without human beings, remains a great mystery. In the instant that Helen Keller understood that the word "water" was the name of the thing, water, she suddenly wanted to know the name of everything. Language was born in her, and suddenly she was no longer an animal but rather a human person. No one yet understands how this "miracle" happened.

Most people in our culture have been taught that death has the last word — not just for us individually, but for our earth as well. In science, it's called "entropy." Now, when death has the last word, the primary issue of life turns out to be survival. When survival becomes one's god, then the questions become "Who is to survive?" and "Who is to decide?" Some people begin to claim superiority over other people. The dominant ones employ the sciences to support their claims by measurements which say that the dominant ones are superior. (Every kind of educational and psychological testing — including I.Q. — demonstrates this assertion.) Unless we have some reason for believing otherwise, we all turn out to be "social Darwinists," who believe we should survive because we are the "fittest." The poor and oppressed of this world understand this well enough. All our institutions reflect it.

I don't believe one person's ethical opinion has the same value as another's. There are better and worse opinions — you must at times say to a neighbor, "You're wrong." If you say there is no right and wrong except in opinion, then you are a moral relativist. I believe that justice, freedom, and love are not just relative matters of opinion — but are objective realities, under which we stand and to which we are accountable. Contrary to the claims of idealists, our problem is that we cannot know the full meaning or specific content of these realities. Neither our understanding of them nor our attempt to make them real in the world are ever absolute. The best we can do in society is to keep striving to approximate justice, equity, and freedom. For this reason, society needs continually to be reformed. □

To Find a Job, Open Eyes and Friendships

Some advice from James W. Davidson, '52, who heads his own company in the executive search field, to 150 alumni attending a Career Counseling Clinic sponsored by the M.I.T. Alumni Center of New York last winter:

— If you think there should be a new job in your future but don't know when: "Always keep your eyes open." Keep track of friends and cultivate acquaintances. If you can help an executive search or employment recruiter in your present job, do so; you may need him yourself some day.

— If you're out of work and looking: "The most effective way to find a job is through contacts — friends, friends of friends, through people you know. It's important to meet and know people."

A smattering of other advice from other Clinic speakers:

William Joyce, Executive Vice President of Cabot and Ballentine: The professional company personnel man is the professional

job-hunter's biggest antagonist. Personnel people "tend to be very conservative, very much concerned with how the applicant fits into 'the total picture.' If you're a creative, innovative person, a self-starter, the personnel staff person may be your biggest enemy."

Mr. Davidson: Looking for a job can be a full-time job; searching out and following through on them takes time and energy. But don't get discouraged: as an M.I.T. alumnus you can have confidence in your ability to find a job because you are good at something, or you can become good at something.

David S. Woronoff, '59, consultant: The higher the job you aim for, the more you should know about the company to which you're applying and the industry it's in. If your research on the company doesn't answer all your questions, call up and ask; but if for some reason you find yourself connected to the person you're preparing to interview, hang up. You're not ready yet, and you need the initiative on your side, as it is in an interview. □

Under the Dome: Cooperation with the Museum and in Spain; Aid to Guatemala; the 20-Cent Lunch

"Vibrant. . .Warm. . .Funny. . .'Fiddler' "
The local critics were unanimous: "Fiddler on the Roof" as produced this spring by the M.I.T. Musical Theater Guild was "a notable success. . . . Executed masterfully, a warm, funny, and poignant 'Fiddler' that will be remembered as one of the Theater Guild's finest efforts. . . . a vibrant performance . . . excellence of choreography . . . superlative upon superlative," wrote Deborah Rubin, '77, in *Thursday*. For *The Tech* Tina Krontiris wrote about "a delightful and vivacious production . . . beautifully choreographed. . . . I think everyone should see it."

A Two-Way Street to the Museum
Interviewed by Michael D. McNamee, '76, Editor-in-Chief of *The Tech*, Howard W. Johnson during the winter said he was challenged by his new job as President of the Trustees of the Museum of Fine Arts, Boston. There's no conflict with his job as Chairman of the M.I.T. Corporation, Mr. Johnson said; indeed, he thinks M.I.T. can be an asset to the Museum, and vice versa. "I'm considering joint programs with the several universities in the area . . . that utilize each institution's greatest strengths — scientific studies at M.I.T., art history at Harvard, history at Wellesley, and so forth — and lend the Museum's strengths to them," he told Mr. McNamee.

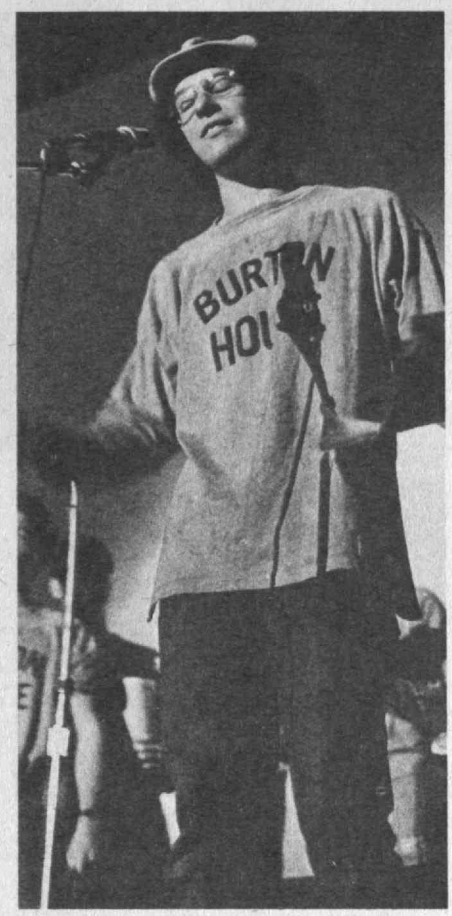
Via CARE to Guatemala
More than $3,000 went to CARE from the M.I.T. campus in March to be used in earthquake-ravaged Guatemala. Alpha Phi Omega raised $2,125, and the balance came from activities during a Guatemala Relief Week, the M.I.T. Catholic community, and individual donors.

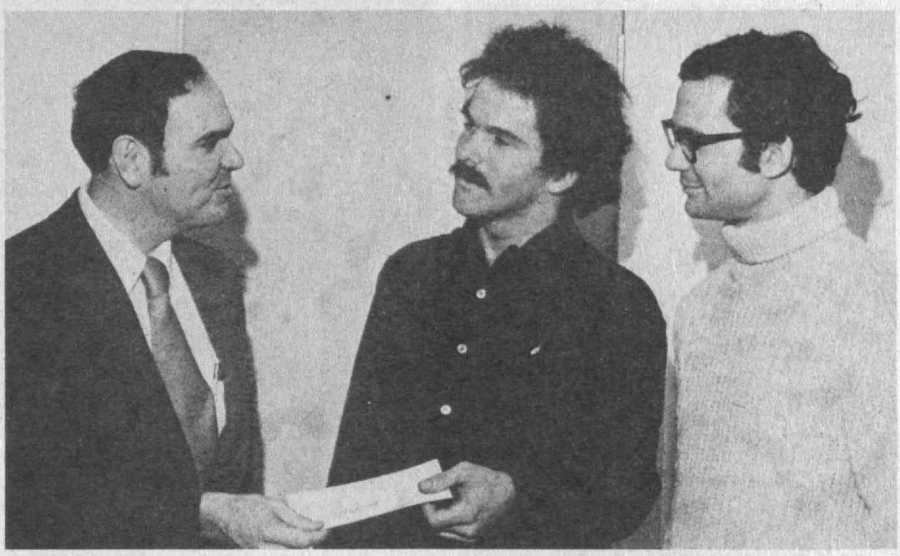
Plum Pudding with Two Sauces, 20 Cents
How many of Ellen A. King's meals did you eat? Ms. King supervised the Tech Lunchroom in the Pierce Building near Copley Square for 18 years beginning in 1891, and now a 23-page manuscript of recollections has come to the M.I.T. Historical Collections. "There was so much to learn," wrote Ms. King when she started the job having had no restaurant experience at all. A typical lunch cost 20 cents, and no one counted calories: "No one hesitated to eat a large amount of rich plum pudding with two kinds of sauce. There were big cups of coffee and baskets of apples. . . ."

Research Collaboration in Spain
Can M.I.T. help Luis de Guzman, S.M. '60, and several Spanish industrialist-colleagues establish an independent post-graduate technological institute in Spain? William F. Pounds, Dean of the Sloan School of Management, and Frederick J. McGarry, '50, Professor of Materials Engineering, have spent two years visiting with Mr. de Guzman and studying the support which might be available, and early this spring they reported to the M.I.T. faculty: "Research collaboration with Spanish professionals can be done and can be mutually rewarding. . . . We also conclude that Spanish support for the technological institute appears sound, stable, prudent, realistic, and effective."

After the Blood Came the Beer
Vinay N. Reddy, '78, is "pretty happy" with the results of the M.I.T.-Red Cross spring blood drive: 1,465 pints, up significantly from last year's 1,392 pints. M.I.T. thus maintains its record as "the largest institutional blood donor in Massachusetts," says Mr. Reddy, who is Blood Drive Chairman for the Technology Community Association.

T.C.A. arranged prizes — undisclosed amounts of beer — to living groups for highest participation in the blood drive. The winners among the dormitories: Conner fourth floor, 72 per cent; Conner fifth, 68 per cent; and Burton third, 48 per cent. Theta Chi led the fraternities with a record-breaking 100 per cent; then came Student House (97 per cent) and Phi Kappa Theta (93 per cent). To Sigma Chi and Delta Upsilon, both of whom topped 80 per cent, the Interfraternity Conference provided special rations of beer as its own part in the general celebration. □





"To record for all time . . . an effort by a private institution which is unparalleled anywhere in New England and matched by few in the entire United States," says a resolution of the Cambridge City Council. The subject of the accolade is M.I.T., and the occasion the Institute's completion of a turnkey project yielding 684 units of housing for low-income and elderly families in various parts of the city. The resolution is here being held by Cambridge Mayor Alfred E. Vellucci (right, photo at top left), who's about to turn it over to Walter L. Milne, Special Assistant to the President for Urban Affairs.

(Top, right): *Many different talents came forth for the All-Tech Sing in April; the picture shows David A. August, '76, fronting for the Burtones of Burton House.* (Above): *The Group School, a private alternative high school in Cambridge, is one of 11 agencies that receive support from M.I.T.'s Community Service Fund; the picture shows Joseph S. Collins, Secretary of C.S.F., handing a $2,500 check to Michael J. Riley, '69, mathematics coordinator for the School.*

The M.I.T. Club of Mexico City annual fiesta: Paul and Ginny Weamer, '49, enjoy "Noche Mexicana" festivities at "Nish" Cornish's house (center, top); a boat sails through "the Mexican Venice", Xochimilco (center, bottom); clockwise from top left: the Piñata; "Nish" Cornish, '24, and Howard Richardson, '31; Ginny Weamer tries to break the Piñata; Sam Goldblith, '40, Fiesta guest of honor; Ann and Bernie Kosco. (Photos: Joseph J. Martori)

In Engineering, the Cost of Being Black Is High, the Reward a Prospective Dilemma

Blacks entering science and engineering are travelers pressing into a foreign land, an unfamiliar culture which has been dominated throughout its history by the white western tradition.

But in the decades to come, it will be the black engineer who can introduce this white, industrialized west to the peoples and cultures on which it will increasingly depend for resources of energy and materials.

Then the black engineer will truly realize his destiny, says Herbert Charles, Personnel Development Manager at Corning Glass Co. But at the same moment of genesis, he will also confront a terrible dilemma: what shall be his role in the process of allocating the fruits of these resources between industrialized white and developing black worlds?

What if you're now studying at M.I.T. and you want to prepare for this role? "Don't look at yourselves as engineers," is Mr. Charles' advice. "Try to understand what this world is all about. You will truly understand the role of the black professional in society when you truly understand the world," he told the 1976 M.I.T. Black Students' Conference on Science and Technology early this spring.

Black Until You Die

To open the Conference, Harry L. Morrison, Professor of Physics at the University of California (Berkeley) who is Visiting Scientist at M.I.T. this year, spoke of the "black lineage" — the cultural traditions which every black shares and which are foreign to whites, and of the need to understand and maintain this lineage in today's increasingly integrated world, to help those around you who share it.

The theme was persistent throughout the 1976 Conference, the fourth in an annual series sponsored by the M.I.T. Black Students' Union. Blatant discrimination has largely been eliminated in the U.S., but participants made it clear that the way is not wholly clear for a black who seeks to enter the white's world of science and engineering.

Such a black will be judged by whites according to white patterns of learning and behavior. He will experience a series of psychological pressures to conform "which have nothing to do with academic quality," says John B. Turner, Assistant Dean of the M.I.T. Graduate School. It is these pressures that are the crucial issues — the reason why so few blacks have attempted careers in science and engineering, and why even fewer have succeeded.

Blacks and whites *are* different — in language, sensitivites, values, opportunities. When you try to enter the world of science and engineering, you have a two-fold challenge — science *and* people, said Donald Bradman, Personnel Recruiting Officer for Western Electric Co. "A portion of your creativity will have to be dedicated to breaking down barriers," Mr. Bradman told his audience of M.I.T. students. "You have to be like the infantry — go in, face the resistance, root out the problem. . . . Change minds, ideas, and ways of thinking."

It's what John Mims, former Assistant Director of Admissions at M.I.T. who is now a student in Harvard's Graduate School of Education, calls the black's "hidden agenda."

"Whites expect blacks to assimilate into the community, to be just like whites." It's racism of a subtle kind, unintended but potentially devastating.

"When are they going to quit treating me like a black?" a student once asked Mr. Mims. His answer: "When you die!" □

Left to right at the opening session of the 1976 Black Students' Conference on Science and Technology: Robert P. Pinckney, '52, Draper Laboratory; Morris Morgan, General Electric Co.; Arlene Maclin, Lincoln Laboratory; Lucy Anderson, U.S. Corp.; and Ernest M. Cohen, '64, Foxboro Co. (Photo: Kevin Campbell)

Law: Spectrum of Grey

The lawyer is not Don Quixote, seeker of absolute truth. His art is to fit the precise statutes of the law into confused, imprecise situations. Hence this advice to M.I.T. undergraduates from Jeptha H. Wade, Esq., '45: Don't go into law if you are looking for the psychic security of black and white issues; you will only find a spectrum of grey. Here is some more wisdom from Mr. Wade's experience, offered last fall:

You must have the ability to compromise. One of the principle functions of a lawyer in litigation is to administer his clients' costs with the knowledge of risks and rewards. And he must decide when it pays to settle and when it doesn't. Because litigation is expensive and the two sides only partially right and partially wrong, a settlement is usually in a client's best interest.

The law has invented some useful synthetic personalities, such as the corporation (which orders the relationship between those who administer it), the partnership, the cooperative, and the trust (a way of turning property over). "It may sound dull, but it's the stuff of which society operates."

The small town lawyer's life may appear idyllic, his practice diverse. But he is *not* under less pressure than his urban colleague. "I have others to help me," said Mr. Wade, whose practice is in metropolitan Boston. "He has *all* the responsibility. And one thing about the world — things come in bunches. Just when you think you have no more time, the roof falls in on you."

"At least 20 per cent of what I do I call my 'psychiatric practice,' " Mr. Wade explained — simply providing service to someone who needs someone to talk to. The chief of a corporation is indeed the proverbial lonely man.

If all this sounded intriguing, said Mr. Wade, a word of warning: law school is "like three years of marine boot camp. Make sure you are interested in law as such. I found the competition is about twice as tough as any you find at M.I.T. You will be tested more; you'd better enjoy it." □

Design for Aerospace: The Ultimate Systems

The aerospace industry's growth has slowed, aerospace engineering enrollment is down 75 per cent in a decade, and aerospace departments in engineering schools are closing throughout the U.S.

Under these conditions, why buck the tide and study aerospace engineering?

Because a good aerospace engineer is uniquely "a highly trained generalist able to interweave several disciplines to achieve an optimum system," writes Rene H. Miller, Head of the Department of Aeronautics and Astronautics.

All kinds of technological problems enter into aircraft and spacecraft design and construction: the mechanical disciplines of fluid mechanics and thermodynamics, the civil engineering field of structural design, the electrical disciplines of circuit analysis and electronics.

In aerospace engineering all these subjects are applied to flight systems where weight and performance are of paramount importance — a set of criteria as rigorous as could be demanded of an engineer in any field. Because "trivial problems suddenly become nontrivial in flight," writes Professor Miller in *Astronautics and Aeronautics (January, 1976, p. 29)*, "the aerospace engineer has been trained to tackle the difficult problems represented by the unknown unknowns." □

Genetic Engineering: A Fateful Union of Science and Humanities

Will the sciences and the humanities ultimately abandon their posts as irreconcilable combatants in the human arena?

Perhaps, thinks Robert L. Sinsheimer, '41, Chairman of the Division of Biology at California Institute of Technology. But not yet, alas.

For evidence he might have turned to *The Tech* for December 2, 1975, in which 17 faculty and staff in architecture, humanities, political science, technology studies, and foreign languages and literatures wrote (responding to an earlier report on nuclear power generation), "The world into which we were all born freely sharing is being so corrupted that one has to pay for clean air and water: our powerlessness to halt these encroachments even makes us doubt our right to clean air, water, and soil. But we must not be so numbed by the relentless energy needs of our technologically oriented society that we surrender our health, our lives, and our unborn children to some horrible nightmare of 'prosperity.' We must try to decipher the official propaganda and be clear about just what bill of goods we are being sold."

Is reconciliation possible? If so, thinks Dr. Sinsheimer, it will be because the humanities and the sciences finally realize that both "represent projections of the human mind, ways in which the human mind seeks to encompass the human experience."

The intersection which Dr. Sinsheimer foresees is being forged by human genetic engineering: "The humanist must finally recognize that many of our peculiarly human qualities are, in fact, shaped by our genes. . . . And the scientist must finally recognize that to reshape man is not a beguiling laboratory experiment but an enterprise that involves the ultimate exercise in value judgment," writes Dr. Sinsheimer in Caltech's *Engineering and Science* magazine.

"To use our heritage to change our heritage is to take the full responsibility for human destiny. The potential of human genetic engineering will draw science into the mainstream of the humanities and the humanities into the mainstream of science — a most fateful union." □

R.O.T.C. Swinging Again

R.O.T.C. programs, once banned or banished to dark, secluded corners on many American campuses, are back in the limelight. And while national enrollments are up an average of 25 per cent, M.I.T.'s three cadet corps — Army, Navy, and Air Force — were up a generous 40 per cent last year, and even more students are enrolled this year.

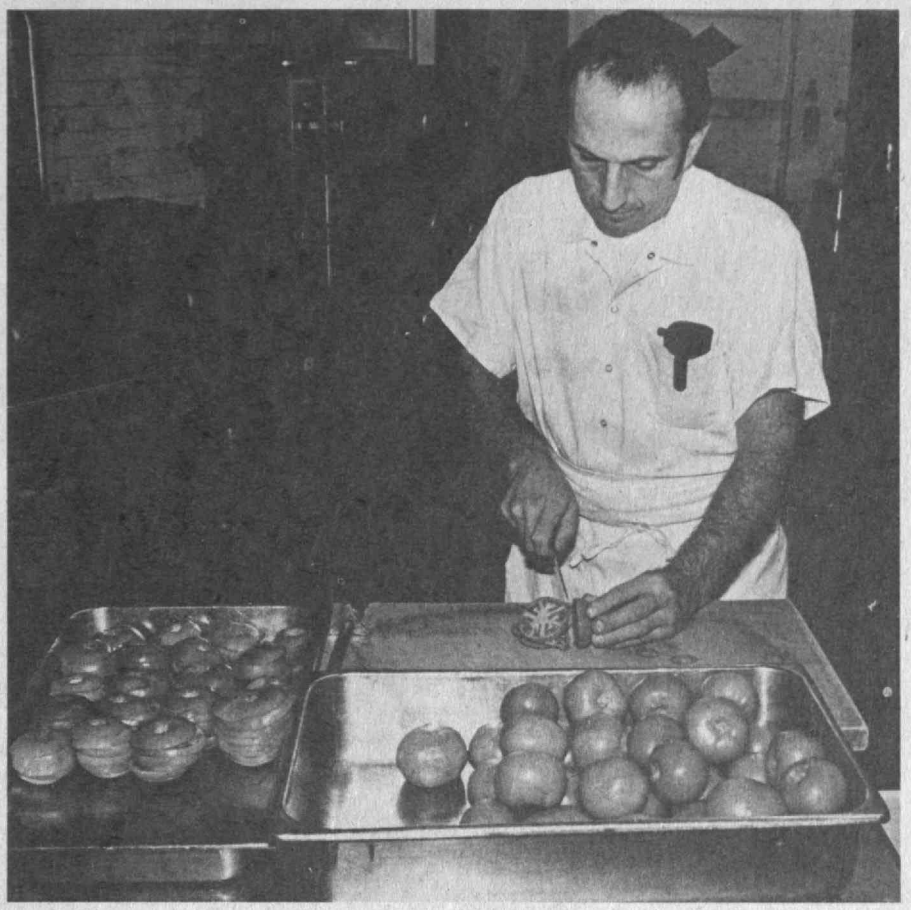
Last year, for the first time, women were enrolled in all three R.O.T.C. programs at M.I.T. That record is maintained — and then some — this year with the arrival of women from Wellesley and Northeastern to join four M.I.T. women enrolled in the Air Force R.O.T.C. program.

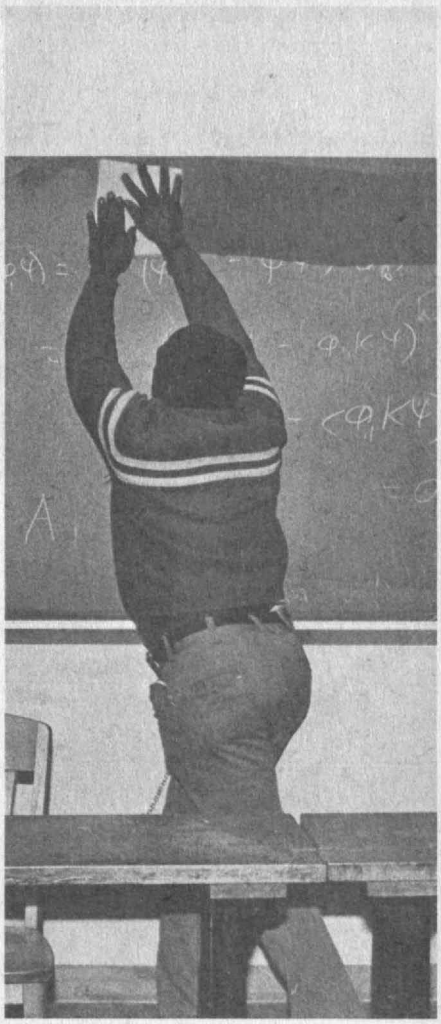
Wellesley participation in M.I.T./R.O.T.C. programs has been possible since the start of the Wellesley-M.I.T. academic exchange nearly ten years ago. Now M.I.T. and Northeastern have agreed that Northeastern students interested in Air Force R.O.T.C. — there is no program at Northeastern — may study at the Institute. Fourteen students chose to do so, bringing significant growth to the Institute's Air Force cadet corps. □

Our Newest Cambridge Neighbor

Remember when it was "research row"? — the three-mile north bank of the Charles River along Memorial Drive in Cambridge?

After World War II Memorial Drive was eclipsed by Route 128 as a base for industrial technology, and the transition continues: the newest Memorial Drive edifice rising just west of M.I.T. (looks like an ancient Aztec pyramid) is a $26 million, 500-room Hyatt Regency Hotel, due to open July 4, 1976. The usual Hyatt Regency features are included: 14-story atrium lobby, revolving roof-top cocktail lounge, glass-enclosed elevators. Rates from $35 single, $45 double.





What happens at M.I.T. at night? To answer the question for The Tech, *David P. Herwaldt, '77, went snooping with his camera. He found "Tech tools," night cleaners, the Campus Patrol, and cooks in "unceasing activity . . . a large city freely accessible 24 hours a day . . . absolutely fantastic openness and vulnerability." But "it has to be that way — so much goes on at night," he concluded.*

Scenes of triumph for the M.I.T. Symphony Orchestra and for the arts at the Institute, photographed at the Kennedy Center in Washington on April 19: Conductor David Epstein and Soloist Marcus Thompson after the performance of Paul Hindemith's "Der Schwanendreher"; Melanie Cognetta, Concertmistress (of Wellesley), relaxing at the post-concert champagne reception; and Professor Epstein with Luis A. Ferre, '26, and Professor Roy Lamson of the Council for the Arts, with President Jerome B. Wiesner in the background at the reception.

"Happiness" in Music: The M.I.T. Symphony in Washington

There's "a great deal of happiness" in the job of being President of M.I.T., says Jerome B. Wiesner. And most of it comes through the association with young people which is assured by the task of running a leading educational institution.

One of the happy moments — the one which inspired that observation by President Wiesner — came at the end of the M.I.T. Symphony Orchestra's triumphant concert in the John F. Kennedy Center for the Performing Arts in Washington, D.C., on April 19. The Orchestra had already spoken for itself — "extraordinary musicians," said President Wiesner; "a first-class university orchestra," wrote Paul Hume in the *Washington Post*. But after the concert Dr. Wiesner wanted to speak to the audience of 2,000 proud alumni and parents of his faith in these young people — competent in intellectual as well as artistic and social pursuits, and by the combination of these assuredly among the nation's future leaders.

To Luis A. Ferré, '26, Chairman of the Council on the Arts at M.I.T. which made possible the Orchestra's Washington appearance, the concert confirmed "a new emphasis at M.I.T. on happiness in its broadest sense. . . . A new ball game in Cambridge," he said: the use of science and technology — and music, the arts, and the humanities, too — as tools to "obtain happiness of humans everywhere."

"Just as the world of today understands that technology is not enough," said Mr. Ferré, "engineers at M.I.T. are learning the importance of beauty."

The concert was a blend of familiar and unknown: Brahms' Academic Festival Overture; Paul Hindemith's "Der Schwanendreher," with Marcus Thompson, Assistant Professor of Music, as viola soloist; "Fantasia on a Theme by Thomas Tallis" by Ralph Vaughan Williams; and Aaron Copland's "Dance Symphony." David Epstein, Professor of Music, conducted. □

"The Might of M.I.T. is Clearly Well Divided Between the Sciences and the Fine Arts"

Paul Hume of the Washington Post *found the M.I.T. Symphony Orchestra's Kennedy Center program on March 19* (see left) *a convincing demonstration by a "first-class university orchestra." Here is his review, reprinted by permission from the* Washington Post *of March 20.*

The M.I.T. Symphony Orchestra came to town last night and its students of architecture, biology, computer science, earth and planetary science, physics, psychology and urban planning had no difficulty in sounding like a first-class university orchestra.

Under the expert conducting of David Epstein, the players from the Massachusetts Institute of Technology and Wellesley offered their Kennedy Center audience a program that would greatly honor the lists of any of our major orchestras. It was of a kind that the majors all too rarely put together.

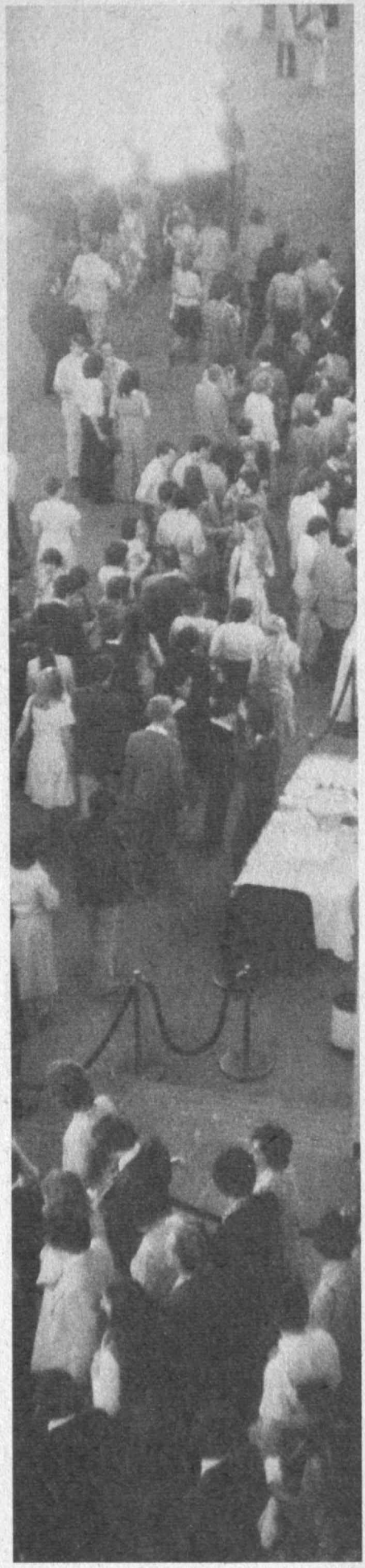
After a well-paced and skillfully balanced account of Brahms' Academic Festival Overture, Epstein introduced Marcus Thompson, a member of the M.I.T. faculty and a superb violist. (Thompson, incidentially, is playing a concert tonight in the Rockville Civic Center which all those interested in the finest kind of viola playing will want to hear.)

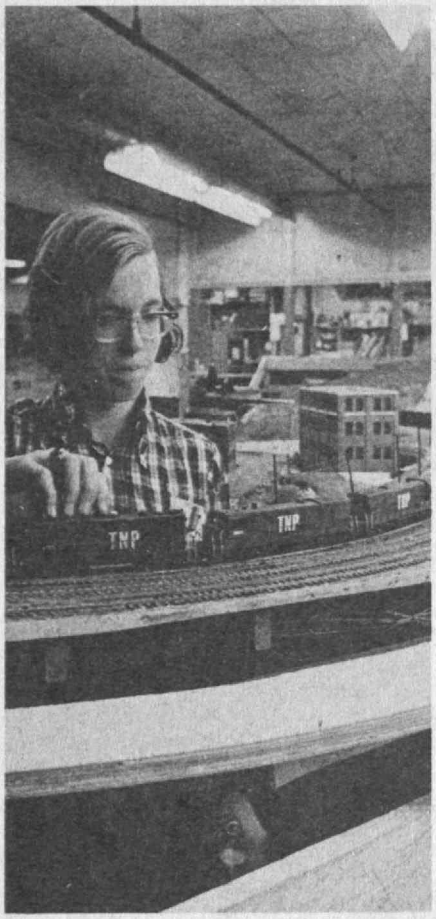
Thompson was soloist in Paul Hindemith's folkish rhapsody called "Der Schwanendreher." It would be interesting to know just how often this music has been heard in Washington in the 40 years since the composer was its soloist with an orchestra conducted by Carlos Chavez. The orchestra for this music consists of wood and brass winds, harp, piano, timpani, cellos and double basses. Thus Hindemith imaginatively provides a luxuriant backdrop for the viola while keeping its voice the highest stringed instrument in the works.

Each of the three movements introduces contrasting German folk songs, the last of which, "Seid ihr nicht der Schwanendreher?" gives the work its title. Thompson is an elegant musician who plays with great style and handsome, silky tone. The work used to be called knotty or thorny, and its composer himself did not always provide the most attractive kind of viola sound when he played it. Perhaps it has been waiting for more violists like Thompson and his famous teacher, Walter Trampler, to smooth out its rougher aspects.

The intricate instrumental support is like a jeweler's showroom in the way it gleams with sudden bursts of sound from instruments that are given unusual assignments. The playing, of chamber orchestra character, was very well handled.

Finally came Aaron Copland's brilliant, jazzy Dance Symphony. This is a big, tough piece for any orchestra. At times last night the going was less smooth than it had been most of the evening, and tone and intonation had problems. But the music was all there and admirably spirited. And again it was a distinct pleasure to hear neglected music. The might of M.I.T. is clearly well divided between the sciences and the fine arts.





The Tech Nickel Plate, operated by the M.I.T. Model Railroad Club, is probably the largest model railroad on any university campus. Now it has an added distinction: it's fully computerized with a train control and communications system.

The Tech Nickel Plate Is Computerized; the Largest, Most Technological University System?

The omnipotent computer has made another conquest: the Tech Nickel Plate Railroad. That's the model railroad operated for nearly three decades by the M.I.T. Model Railroad Club. It's probably the largest, almost surely the most sophisticated model railroad on a university campus.

The computer's assignment is to manage Tech Nickel Plate traffic — to assemble and route trains; to operate switches; to move traffic from main lines to sidings and back again. It also prints out train consists, listing cars and their programmed destinations anywhere on Tech Nickel Plate's 1,000 feet of track system.

That figure — 1,000 feet of mainline track — is only an estimate; nobody knows for sure. The system began on a portable "breadboard" used for technical demonstrations of railroad developments just after World War II, and it's grown casually ever since then to occupy two large rooms in Building 20 — the World-War-II "temporary" building which has turned out to be nearly permanent. Construction and instrumentation continue; the Tech Nickel Plate will never be "completed," thinks Michael A. Patton, '77, its Co-Governor.

Two synchronized digital clocks operate at ten times normal speed and an internal telephone system connects the various operating positions. Ten times normal speed? That's to correct for the HO-scale trains — ⅛ inch to the foot.

In addition to the Tech Nickel Plate — five trains can run simultaneously on its tracks — there's a subsidiary interurban service, a collection of villages whose buildings offer some humorous commentaries on the human condition, and mountains and scenic features.

During the academic year "operating sessions" usually occur every Friday night at 8:30 and feature scheduled passenger train operation using the scale time digital clocks and "card order" freight operation in which the computer generated paperwork accompanying real world freight car shuffling is faithfully duplicated.

In addition to the operation of model trains, club members go on periodic "rail fan" trips from which photos are shown at monthly "Slide and Movie Night" presentations in the classroom adjacent to the clubroom.

Over two dozen undergraduates, several graduate students and alumni are counted among the Club's active members. Operations are likely to be conducted at any time, day or night, week or weekend — depending simply on the arrival of enough members to man the system. □

Cooperative Study: The Boom at VI-A

"I wish we had openings for all of them."

. . . A typical corporate remark after interviews with M.I.T. students looking for places in the cooperative program in electrical engineering and computer science (Course VI-A), says John A. Tucker, Director of the program.

But popularity of the Course is at an all-time high, and the companies associated with M.I.T. in the cooperative program will have room for only about half of the students who applied, says Mr. Tucker.

This spring 140 students — 56 per cent of the sophomores in Course VI (Electrical Engineering and Computer Science) — applied for places in the cooperative program; cooperating companies had 70 places available for the work/study students. Students who are accepted will undertake two — sometimes three — work assignments with a company before completing undergraduate degree requirements at M.I.T. — typically two periods of summer employment and perhaps one period of term-time work. They will have unusual on-the-job experience, and they will be paid by the companies during their work assignments.

A good deal all around, thinks Mr. Tucker: "There's nothing better than coupling engineering education with the real world of engineering to produce students more immediately productive as they enter their field of training," he says, and he believes Course VI-A students have "brighter job prospects" than most other undergraduates.

The selection process is mostly in the hands of the companies; they interview Course VI-A applicants and invite those in whom they're interested to take work assignments. This year, with a record number of applicants, Mr. Tucker's office arranged for 714 company-student interviews. □

The lobby of the Rogers Building — Building 7 — is a classic and stately (pompous?) monument to the Institute's station. Now it is also, often, a community meeting place for entertainments of all kinds — M.I.T.'s "concourse of experience," says Tech Talk. *The sundial, a creation of Mark Faverman who is a Fellow at the Center for Advanced Visual Studies, was accurate for the hours from 1 to 4 p.m. when spring sun enters the filigreed windows. (Photos: Daniel Lam, Roger N. Goldstein, '74, and Richard Goduti)*

People

C. K. Colton

E. G. Cravalho

R. de Neufville

C. F. Dewey, Jr.

Faculty Promotions: Eighteen Professors

Eighteen promotions to the rank of full professor — the highest regular faculty rank — were announced this spring. They are:

— **Clark K. Colton,** Ph.D. '69, Department of Chemical Engineering. At M.I.T. since 1964, Professor Colton's work has been mostly in the application of chemical engineering to problems in medical practice and biological science, including mass transfer processes and enzyme technology. He is in charge of courses in enzyme technology, artificial internal organs, and chemical engineering in medicine.

— **Ernest G. Cravalho,** Department of Mechanical Engineering. A graduate of the University of California (Berkeley), Professor Cravalho is known for research on the application of cryogenics to biology and medicine — including especially the preservation by freezing of blood cells. He is Associate Dean for Educational Programs of the School of Engineering, and his teaching is in the molecular theory of materials and radiation heat transfer.

— **Richard de Neufville,** '61, Department of Civil Engineering. Dr. de Neufville is Chairman of the Technology and Policy Program in the School of Engineering, and he has pioneered in organizing and teaching interdepartmental systems analysis courses in the School; his professional specialty is airport planning. Professor de Neufville was White House Fellow in 1965-66 and in 1970 was Director of the Civil Engineering Systems Laboratory.

— **C. Forbes Dewey, Jr.,** Department of Mechanical Engineering. At M.I.T. since 1968, Professor Dewey studied at Yale, Stanford, and Cal. Tech; his research has been in high-speed aerodynamics including boundary-layer theory and free-molecular flow; low-density plasmas; nonlinear optics; biomedical fluid mechanics; and industrial and medical instrumentation.

— **Robert M. Fogelson,** Department of Urban Studies and Planning. Urban history, violence, and the role of the police have been Dr. Fogelson's research subjects; he is in charge of the course on Institutional Change in Urban America. At M.I.T. since 1968, Dr. Fogelson studied at Columbia and Harvard.

— **Malcolm L. Gefter,** Department of Biology. Professor Gefter holds the 1975 Pfizer Award in Enzyme Chemistry and he is a member of the editorial boards of journals in biochemistry and biophysics; he teaches in the General Biochemistry course, and his research is centered in cellular differentiation and the biosynthesis of DNA. Dr. Gefter came to M.I.T. from the Columbia faculty in 1972; he studied at the University of Maryland and Albert Einstein College of Medicine and held a postdoctoral appointment in Cambridge, England.

— **John B. Heywood,** Ph.D. '65, Department of Mechanical Engineering. Dr. Heywood's specialty is the design and operating characteristics of internal combustion engines, including the trade-offs between performance, efficiency, economy, and emissions; he is Director of the Sloan Automotive Laboratory and a member of the Operating and Steering Committees of the M.I.T. Energy Laboratory. A native of England, he came to M.I.T. for graduate study from Cambridge University.

— **Steven L. Kleiman,** '61, Department of Mathematics. Professor Kleiman's special interest is algebraic geometry, a field in which he has earned distinction as teacher and writer. He came to M.I.T. in 1969 from the Columbia faculty, following graduate study at Harvard and a series of postdoctoral fellowships for study in France and Denmark.

— **Lawrence M. Lidsky,** Ph.D. '62, Department of Nuclear Engineering. A longtime worker in the field of controlled fusion, Dr. Lidsky now has responsibility for the Department's teaching in applied plasma physics and fusion reactor technology. He has made important research contributions and has served as consultant to fusion programs in both government and industrial laboratories.

— **Harvey F. Lodish,** Department of Biology. A molecular biologist, Dr. Lodish's work is in protein biosynthesis and differentiation in complex biological systems; he is Chairman of the 1976 Gordon Conference on Animal Cells and Viruses. A graduate of Kenyon College and the Rockefeller University, Dr. Lodish came to M.I.T. in 1968 following postdoctoral work in Cambridge, England.

— **Stewart C. Myers,** Sloan School of Management. Dr. Myers came to M.I.T. as Assistant Professor of Finance in 1966; his major professional interests are corporate financial policy and the financial aspects of government regulation. His degrees are from Williams and Stanford, and he is active in professional societies in the field of finance and applied economics.

— **Alan V. Oppenheim,** '61, Department of Electrical Engineering and Computer Science. Digital signal processing applied to speech and visual images is Dr. Oppenheim's special field; earlier research involved nonlinear systems and nonlinear filtering problems. Dr. Oppenheim's degrees are all from M.I.T. (Sc.D. 1964), and he has been a member of the staff since 1961 except for two years at Lincoln Laboratory and a one-year leave of absence (1972-73) at the University of Grenoble, France.

— **Regis M. Pelloux,** Sc.D. '58, Department of Materials Science and Engineering. After completing his graduate studies, Dr. Pelloux served for two years in the French Army and for seven years in Boeing Co.'s Scientific Research Laboratories. At M.I.T. since 1968, he has worked on electronic methods of fracture detection and on fracture micromechanisms; he is in charge of the Department's several courses in the structures and mechanics of materials.

— **James K. Roberge,** '60, Department of Electrical Engineering and Computer Science. A specialist in electronic circuit and system design, Professor Roberge is the author of books on electronic components, electronic measurements, and operational amplifiers; he is in charge of the basic undergraduate course in electronics and of advanced courses in solid-state circuits. Dr. Roberge has been a member of the faculty since completing his doctorate at M.I.T. in 1966.

— **Daniel Roos,** '61, Department of Civil Engineering. Dr. Roos has been technical director of a number of M.I.T. projects applying computer technology to the solution of civil engineering systems problems; his

R. M. Fogelson

M. L. Gefter

J. B. Heywood

S. L. Kleiman

L. M. Lidsky

H. F. Lodish

principal current research is in demand-responsive transportation systems such as "dial-a-bus." Dr. Roos is Chairman of the Paratransit Committee of the National Academy of Science.

— **Jerome H. Saltzer,** '61, Department of Electrical Engineering and Computer Science. Head of the Computer Systems Research Division of the Laboratory for Computer Science, Dr. Saltzer has been active in formulating the present undergraduate curriculum in computer science — including development of the core subject on the engineering of information systems. He has also worked on the design of time-shared and multiplexed information systems since joining the faculty following graduate study in 1966.

— **David H. Staelin,** '60, Department of Electrical Engineering and Computer Science. A radio astronomer, Dr. Staelin has specialized in microwave spectra of planetary atmospheres; he has also studied pulsar emission characteristics and is a codiscoverer of the famous pulsar in the Crab Nebula. Dr. Staelin joined the faculty upon completing his doctorate in 1965.

— **Gerald L. Wilson,** '61, Department of Electrical Engineering and Computer Science. Dr. Wilson is Director of the Electric Power Systems Engineering Laboratory, and he has been Philip Sporn Associate Professor of Energy Processing since 1970. His teaching and research are in the field of power system engineering, and he has made important contributions in the field of electric power transmission and control systems. □

Names in the News

Major faculty and administration changes announced during the spring:

— **Allan S. Bufferd,** '59, formerly Associate Director of the Alumni Fund who has more recently been Institute Secretary in Resource Development, is now Assistant to the Treasurer; he will work on financial and legal aspects of the Institute's retirement plans for employees and staff and help develop and administer gifts to M.I.T. in trust and by bequest. Dr. Bufferd holds three M.I.T. degrees in metallurgy and expects to receive the J.D. from Suffolk University this month.

— **Michael S. Feld,** '63, Associate Professor of Physics, will be Director of the Spectroscopy Laboratory upon the retirement of Professor **Richard C. Lord** on June 30. Professor Feld has worked in the interdepartmental laboratory since joining the faculty in 1968; his special field is laser physics and spectroscopy. Professor Lord is widely honored in the field of optics and spectroscopy; he has been Director of the Laboratory since its designation as an interdepartmental facility in 1946.

— **Morris Halle,** Professor of Modern Languages, is Acting Head of the Department of Foreign Literatures and Linguistics; Professor **James W. Harris,** the Head of the Department, is on leave for the spring term. Professor Halle is no stranger to administrative problems in the Department; he has been administrative officer of the graduate program in linguistics since its inception — in which he was instrumental — in 1961.

— **Frederick C. Hennie III,** '55, Professor of Computer Science and Engineering, will be Executive Officer of the Department of Electrical Engineering and Computer Science effective July 1; he succeeds **George C. Newton, Jr.,** '41, Professor of Electrical Engineering, who will return to full-time teaching and research in the field of control systems and devices. Professor Hennie was a prime mover in the development of separate curricula in electrical engineering and computer science, and he has helped to plan the latter. The Department, with 1,277 undergraduate and graduate students, is the largest at M.I.T.

— Professor **Frank E. Perkins,** '55, who has been Acting Head of the Department of Civil Engineering since July, 1975, is now its Head. He succeeds Professor **Peter S. Eagleson,** Sc.D. '56, who is spending the current year as a visitor at the California Institute of Technology. Professor Perkins' research interests are in hydraulic engineering and water resources planning; he was for eight years Associate Head of the Department's Water Resources Division with special responsibility for academic pro-

S. C. Myers

A. V. Oppenheim

R. M. Pelloux

J. K. Roberge

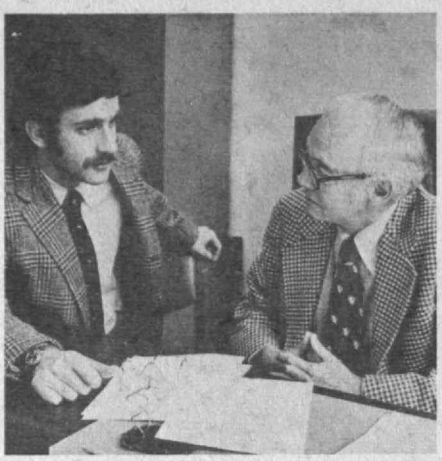
D. Roos

J. H. Saltzer

D. H. Staelin

G. L. Wilson

Michael S. Feld, '63, first worked in the Spectroscopy Laboratory as an undergraduate interested in laser physics and spectroscopy; his research has been centered there since he joined the faculty in 1968. Now Professor Feld (left) will succeed Professor Richard C. Lord (right) when the latter retires as Director of the Laboratory in June.



A. S. Bufferd

M. Halle

D. R. Wilson

grams, and for two years beginning in 1973 he was Special Assistant to the Dean of Engineering for special education programs.

— **J. Kim Vandiver,** Ph.D. '75, is now Henry L. Doherty Assistant Professor in Ocean Utilization, the second recipient of the professorship established in 1973 by the Henry L. and Grace Doherty Charitable Foundation, Inc., to help develop junior faculty interests in ocean resources. The first Doherty Professor, **Francois M. M. Morel,** will continue his work on models for predicting the biochemical behavior of coastal waters. Dr. Vandiver's research and teaching center on the dynamic behavior of structures at sea.

— **David R. Wilson,** '73, has been elected a member (as a Representative from Recent Classes) of the M.I.T. Corporation. He will serve the remaining three years of the five-year term of **Gregory C. Chisholm,** '73, who relinquished his Corporation membership when he re-entered M.I.T. as a special graduate student in mechanical engineering this spring. Mr. Wilson is a control engineer with Corning Glass Works, Corning, N.Y. □

Individuals Noteworthy

Kudos: Honors, Awards, Citations

To **Wayne F. Koppes,** M.Arch. '29, architectural consultant, the 1976 Walter C. Voss Award of the American Society for Testing and Materials . . . **Frank J. Heymann,** S.M. '53, Senior Engineer in the Steam Turbine Division of Westinghouse Electric Corp., Lester, Penn., named a Fellow of the American Society for Testing and Materials (A.S.T.M.) and honored by the A.S.T.M. Award of Merit . . . to **W. H. Krome George,** '40, Chairman of the Board and Chief Executive Officer of Aluminum Co. of America, the honorary Doctor of Science degree of Clarkson College . . . to **Elmer H. Stotz,** '32, Professor and Chairman of Biochemistry at the School of Medicine and Dentistry of the University of Rochester, a citation of outstanding achievement from the alumni of the University.

To **George O. G. Lof,** '40, Professor of Civil Engineering and Director of the Solar Energy Applications Laboratory at Colorado State University, the 1975 Lyndon Baines Johnson Foundation Award . . . to **James R. Killian, Jr.,** '26, Honorary Chairman of the M.I.T. Corporation, the 1976 Peabody Award of the University of Georgia School of Journalism for "outstanding contributions to educational television in the United States" . . . to **Prachees S. Mathur,** Sc.D. '72, Mechanical Metalworking Engineer at the Aircraft Engine Group of General Electric, their annual William L. Badger Award for outstanding technical achievement in materials and manufacturing process technology.

Seven students and former students of the Department of Urban Studies and Planning at M.I.T. were awarded the Ted Aschman Memorial Prize of the American Society of Planning Officials for their paper, *Capacity Building: An Alternative Approach to Citizen Involvement in Planning.* The recipients of the $1000 prize were: **Jay W. Wollenberg,** '75, **Vic Franckiewicz,** '76, **Julie Moir,** former graduate student, **James B. Gust,** '75, **John B. Wilbur III,** '76, **Kay M. Anderson,** '76, and **Elizabeth R. Lund,** '76.

Jay W. Forrester, Germeshausen Professor of Management at M.I.T., to Honorary Membership in the Society of Manufacturing Engineers. Professor Forrester was also selected as the lecturer for the 46th Charles Proteus Steinmetz Memorial Lecture . . . to **Thomas J. Reading,** S.M. '39, Chief Materials Engineer of the Missouri River Division of the Army Corps of Engineers, Omaha, Neb., the Henry L. Kennedy Award of the American Concrete Institute . . . to **Harvey M. Sapolsky,** Associate Professor of Political Science at M.I.T., a fellowship from the German Marshall Fund of the United States . . . **Herbert Goodwin,** '37, Senior Lecturer at the Sloan School of

Management, to a Fellow of the Society for the Advancement of Management.

Appointments: Rising in the World of Business

George J. Marlowe, Sc.D. '50, Executive Vice President of Scientific Design Co., Inc., New York, N.Y. . . . **Michael H. Marx,** '66, to Vice President of Technical Marketing Associates, Management Consultants, Concord, Mass. . . . **John M. Seavey,** '58, Vice President of Engineering for RF Systems, Inc., Cohasset, Mass. . . . **Robert H. Welsh,** '48, Executive Vice President of Ludlow Corp., Needham Heights, Mass. . . . **Daniel J. Gross,** '63, Senior Vice President of Colonial Penn Group, Inc., Philadelphia, Penn. . . . **William Murphy,** '50, Vice President/ Home Office Services for the New England Mutual Life Insurance Co., Boston.

Dennis J. Carney, Sc.D. '49, President and Chief Operating Officer of Wheeling-Pittsburgh Steel Corp. . . . **James P. Reilly,** Sc.D. '67, Vice President for Applied Technology at Avco Everett Research Laboratory, Inc., Everett, Mass. . . . **Grady W. Harris,** '61, Vice President of Product Development for the Artificial Organs Division of Travenol Laboratories, Deerfield, Ill. . . . **Richard J. McGarry,** '44, Business Development Manager of Badger American, Inc., Cambridge, Mass. . . . **Charles H. Pimlott, Jr.,** S.M. '58, Director of Marketing of Stouffer Restaurants, Cleveland, Ohio . . . **Hugo C. Johnson, Jr.,** '46, General Development Manager for the Chemical Plants Division of Dravo Corp., Pittsburgh, Penn. . . . **Claude J. Pasquier,** '50, Vice President of Program Management at the Amecom division of Litton Industries, College Park, Md. . . . **William D. McKinley,** '52, Director of Data Acquisition Systems at the Equipment Division of Raytheon Co., Lexington, Mass. **William J. Hallahan,** '32, Treasurer of the Corporation of Fay, Spofford and Thorndike, Inc., Boston . . . **Paul Loewenstein,** '53, Vice President and Technical Director of Nuclear Metals, Inc., Concord, Mass. . . . **Robert H. Welsh,** '48, Executive Vice President of Ludlow Corp., Needham Heights, Mass. . . . **James R. Reese,** '52, President and Chief Operating Officer of Hydrometals, Inc., Dallas, Tex. . . . **Milton Sanders,** '41, Vice President of Marketing of Electronic Associates, Inc., West Long Branch, N.J. . . . **Norman M. Haller,** M.S. '62, Assistant Director for Safeguards in the Nuclear Regulatory Commission's Office of Inspection and Enforcement.

Vinson R. Simpson, Jr., '50, President of Marathon Electric Manufacturing Corp., Wausau, Wis. . . . **David L. Littman,** M.S. '66, Vice President and Economist in charge of the Economics Department at Manufacturers National Bank of Detroit . . . **Chester W. Diercks, Jr.,** S.M. '62, Chief Financial Officer of Allis-Chalmers Corp. . . . **Frederick J. Milford,** Ph.D. '52, Associate Director of Research at Battelle's Columbus Laboratories . . . **G. Peter Grant,** '67, Director of Corporate Budget and Accounting for Howmet Turbine Components Corp., Muskegon, Mich. . . . **John J. Mahoney,** S.M. '75, Vice President of Operations for Avco Systems Division, Wilmington, Mass.

Appointments: Moving up in Academe

Bryan F. Smith, '42, General Director of Texas Instruments Inc., appointed Chancellor of the University of Dallas . . . **Peter W. Likins,** M.S. '58, to Dean of the School of Engineering and Applied Science of Columbia University . . . **Keith D. Stolzenbach,** '66, Assistant Professor of Civil Engineering at M.I.T., named Arthur D. Little Assistant Professor in Environmental Sciences and Engineering at M.I.T. . . . **Ronald W. Jones,** Ph.D. '56, John Munro Professor of Economics at the University of Rochester, named Xerox Professor of International Economics at Rochester . . . **John B. Goodenough,** leader of the electronic materials group at Lincoln Laboratory, to the chair of Professor of Inorganic Chemistry and Fellow of St. Catherine's College at Oxford University.

Elmer J. Roth, S.M. '35, Director of Financial Affairs at New England College . . . **Frederic W. Nordsiek,** '31, Adjunct Professor in the Department of Nutrition in the School of Public Health at the University of North Carolina at Chapel Hill . . . **Yi H. Ma,** Sc.D. '67, to Professor of Chemical Engineering at Worcester Polytechnic Institute . . . **Alician V. Quinlin,** '68, to Assistant Professor of Environmental Engineering at M.I.T. . . . **Carl R. Peterson,** Sc.D. '63, Associate Professor of Mechanical Engineering at M.I.T.

Items of Interest

Edward T. Thompson, '46, now Editor-in-Chief of *Reader's Digest* magazine . . . **Daniel M. Kelley,** '46, to Publisher of *The Physician and Sportsmedicine* and *Postgraduate Medicine,* two McGraw-Hill medical publications . . . **Bruce Mazlish,** Professor of History and Head of the Department of Humanities at M.I.T., author of a new book, *The Revolutionary Ascetic: Evolution of a Political Type* . . . **Michael S. Baram,** Associate Professor of Civil Engineering at M.I.T., author of a bill recently introduced into the state legislature to govern and encourage the development of solar energy in Massachusetts.

Counselors: Officers, Directors, and Advisors

Kenneth N. Stevens, Professor of Electrical and Bioengineering at M.I.T., to President of the Acoustical Society of America . . . **Richard H. Lyon,** Professor of Mechanical Engineering at M.I.T., to a three-year term on the Council of the Acoustical Society . . . **Rufus Hallmark,** Assistant Professor of Music at M.I.T., to President of the New England Chapter of the American Musicological Society . . . **J. Paul Beliveau,** '47, Plant Manager of Bridgeport Brass, Bridgeport, Conn., to one of three Chairmen of the United Way of Eastern Fairfield

County.

Career Changes

Donald P. Robinson, '56, Associate Curator and Director of Ship's Preservation at Mystic Seaport, Mystic, Conn. . . . **Stephen E. Memishian,** S.M. '70, Vice President and Special Assistant to the President of Columbia Pictures, Burbank, Calif. . . . **John D. Christie,** '59, Assistant Administrator for Policy and Analysis of the Federal Energy Administration, Washington, D.C. . . . **David F. Hoover,** '65, Budget Director of New York University, New York, N.Y. . . . **Charles P. Peck, Jr.,** '41, Acting Vice President for Business Affairs at New Jersey Institute of Technology, Newark, N.J. . . . **James H. Turner,** '61, Chairman of the Department of Physics and Astronomy of Bowdoin College, Brunswick, Maine. **Charles Joyce,** '56, Associate W-30 Technical Director at MITRE Corp., Bedford, Mass. . . . **William S. Coleman,** S.M. '46, General Manager of the Engineering and Research Center of Eaton Corp., Southfield, Mich. . . . **Morse H. Klubock,** '49, Manager of the Marine Division of Perini Corp., Framingham, Mass. . . . Rev. **Max M. Polak,** '67, Chaplain of Warrance College at the New South Wales University campus, Sydney, Australia . . . **August P. Doering,** '50, Manager of Commercial Printing Plate Research of S. D. Warren Co., Westbrook, Maine.

Charles Holcomb, S.M. '75, Commander of the nuclear ballistic submarine *Lafayette* . . . **Frank E. Briber, Jr.,** '43, General Manager of the Cement and Chemicals Division of Allis-Chalmers Corp., Milwaukee, Wis. . . . **Jon K. Clemens,** '63, Group Head of Signal Systems Research at RCA Laboratories, Princeton, N.J. . . . **Gerald S. Meiling,** Sc.D. '66, Development Associate of Technical Product Development of the Technical Staffs Division at Corning Glass Works, Corning, N.Y. . . . **W. Thomas Brydges III,** '62, Business Planning Manager in the Finance Division of Corning Glass Works . . . **Charles H. Stetson,** '56, Director of Rates and Load Research for Public Service Co. of New Hampshire.

New Members of the National Academy of Engineering

Among the 104 new members elected to the National Academy of Engineering were: **Horace S. Beattie,** '33, IBM Corp., Lexington, Ky.; **Donald J. Blickwede,** Sc.D. '48, Bethlehem Steel Corp., Bethlehem, Penn.; **Donald B. Broughton,** Sc.D. '43, U.O.P. Process Division, Des Plaines, Ill.; **Dayton H. Clewell,** '33, Mobil Oil Corp., New York, N.Y.; **Franklin S. Cooper,** Ph.D. '36, Haskins Laboratories, New Haven, Conn.; **F. J. Corbato,** Ph.D. '56, Professor of Computer Science and Engineering at M.I.T.; **Ira Dyer,** '49, Professor of Ocean Engineering and head of that department at M.I.T.; **Richard S. Engelbrecht,** Sc.D. '54, University of Illinois at Urbana-Champaign, Ill.; **Merton C. Flemings,** '51, Ford Professor of Engineering and Associate Director of the Center for Materials Science and Engineering at M.I.T.; **Douglas W. Fuerstenau,** Sc.D. '53, University of California, Berkeley; **John B. Goodenough,** Group Leader of the Electronics Materials Group at Lincoln Laboratory; **Robert C. Gooding,** S.M. '46, Naval Sea Systems Command, Washington, D.C.; **Herman A. Haus,** Sc.D. '54, Elihu J. Thompson Professor of Electrical Engineering at M.I.T.; **Joseph H. Keenan,** '22, Professor Emeritus of Mechanical Engineering at M.I.T.; **John P. Longwell,** Sc.D. '43, Exxon Research and Engineering Co., Linden, N.J.; **Hans M. Mark,** Ph.D. '54, N.A.S.A. Ames Research Center, Moffett Field, Calif.; **James K. Mitchell,** Sc.D. '56, University of California, Berkeley; **Richard S. Morse,** '33, President of the M.I.T. Development Foundation and Senior Lecturer at the Sloan School of Management; **Thomas H. Pigford,** '48, University of California, Berkeley; **Egor P. Popov,** S.M. '34, University of California, Berkeley.

Marshall B. Dalton, 1893-1976: Senior Member of the Corporation, Alumni Leader

Marshall B. Dalton

Marshall B. Dalton, '15, one of M.I.T.'s most active and respected alumni leaders who was for 39 years a member of the Corporation, died on March 29 in Winter Park, Florida. At age 83, he was the senior member of the Corporation in terms of continuous service.

Howard W. Johnson, Chairman of the Corporation, described Mr. Dalton as a devoted alumnus whose "interest in M.I.T.'s well-being ranged from alumni organization and student life to employee welfare. . . . In his passing, M.I.T. . . . and the Greater Boston community lost a distinguished citizen and leader in private philanthropy."

Mr. Dalton's service to M.I.T. and its Alumni Association spanned 60 years, beginning almost immediately after his graduation in civil engineering with the Class of 1915. Mr. Dalton first became a member of the M.I.T. Corporation in 1937, when he was elected President of the Alumni Associa-

tion. He was the first Chairman of the Corporation Development Committee when it was established in 1952, and he had participated in every major capital fund drive of the Institute since World War II — including the $26-million Mid-Century Campaign of which he was Chairman in 1949 to 1952.

Between 1934 and 1949 Mr. Dalton was a member of five different Corporation Visiting Committees; for 11 years, from 1952 to 1963, he was a member of the Executive Committee of the Corporation, and during that time he was on the Corporation's Investment and Membership Committees.

Mr. Dalton, a member of Phi Gamma Delta, was a strong advocate of fraternities at M.I.T. He was a leader in the Alumni Interfraternity Council and a founder of the Independent Residence Development Fund, and in these and other ways he was active in securing resources for his own fraternity and for the fraternity system.

For 20 years after graduating from M.I.T., Mr. Dalton held increasingly responsible assignments in engineering and management at Liberty Mutual Insurance Co. Then in 1934 he became President of Boston Manufacturers Mutual Insurance Co. and in 1937, in addition, President of the Mutual Boiler and Machinery Insurance Co., posts which he held until 1958. For seven years thereafter, until retirement in 1965, he was Chairman of the Board of these companies.

Throughout his career, Mr. Dalton was recognized for his leadership in applying engineering principles to casualty insurance. He played a major role in developing the Factory Mutual System through which several associated insurance companies sponsor engineering activity in loss prevention, risk evaluation, and risk sharing.

Survivors include Mr. Dalton's widow, the former Lydia White, and two daughters, Mrs. Lloyd Plummer and Mrs. Porter S. Wood; the family has requested that contributions in Mr. Dalton's memory be made to M.I.T. or to the Heart Fund. □

Victor P. Starr, 1909-1976

Victor P. Starr, S.M. '38, a member of the M.I.T. faculty in the Department of Meteorology from 1947 until retirement in 1974, died at Faulkner Hospital, Boston, after a brief illness on March 15. He was 66.

In a statement in *Technology Review* at the time of Professor Starr's retirement, Reginald E. Newell, Sc.D. '60, Professor of Meterology, wrote that in the previous 30 years Professor Starr's papers "have been more numerous and more instructive, reporting more new results and more new ideas, than those by any other scientist in our field. [They] have quietly told us how the atmosphere works." Professor Henry G. Houghton, S.M. '27, said at the time of Professor Starr's death that in 27 years as an active member of the faculty he "supervised about a quarter of all the doctoral theses in the Department."

Professor Starr's work was in the fields of the global circulation of the atmosphere, water resources, and solar and planetary astronomy. After taking his degree from M.I.T. Professor Starr joined the U.S. Weather Bureau; then he went in 1941 to the University of Chicago for graduate work and teaching; he came to M.I.T. after receiving his Ph.D. in meterology at Chicago in 1946. □

Kanwar Bidhi Chand, 1929-1976

Kanwar Bidhi Chand, a member of the Laser Group in the Department of Physics, died following a heart attack on April 1. He was 47.

Professor Ali Javan, Head of the Laser Group, describes Mr. Chand's "ingenuity and inventiveness" as "unique and invaluable. He made many basic contributions to our many research projects," said Dr. Javan.

Mr. Chand first came to the Institute as an exchange visitor from the Indian Institute of Technology, Kanpur, in 1968; he rejoined the Laser Group on a permanent basis in 1973. □

Alexander J. Bone, 1900-1976

Alexander J. Bone, '24, who as a member of the Department of Civil Engineering was known as "Mr. Transportation" to generations of M.I.T. students, died on March 30 in Newton, Mass. He was 76.

Professor Bone began his teaching career at the Institute in 1933 while studying for his S.M. degree (1936). He rose through the faculty ranks to retire as Professor, Emeritus, in 1967, meanwhile having been since 1951 Director of the Joint Highway Research Project (with the Massachusetts Department of Public Works) and from 1954 to 1962 Acting Head of the Transportation and Surveying Division of the Department.

As a consultant, Professor Bone was involved in planning the Massachusetts Turnpike and other highway projects in New England and the east, and he worked with the Association of American Railroads, the Railway Association of Canada, and other groups. He directed a two-year analysis of the economic impact of Route 128 which served as a model for similar studies throughout the U.S. □

Deceased

William P. Bentley, '04; April 6, 1976; 4211 Lorraine, Dallas, Tex.
James E. Rogers, '05; March, 1975; 46 Coddington Ave., Staten Island, N.Y.
Stewart C. Coey, '06; February, 1976; Convalescent Center, Hanover, N.H.*
Milton E. MacGregor, '07; March 21, 1976; Baptist Home of Mass., 66 Commonwealth Ave., Chestnut Hill, Mass.
John B. Farwell, '13; March 3, 1976; Taunton Hill Rd., Newton, Conn.*
Edward E. Jewett, '13; March 31, 1976; 9 Doty Ave., Danvers, Mass.*
Louis D. Charm, '14; August 2, 1975; 2346 Centreville Rd., Herndon, Va.
Samuel Berke, '15; April 14, 1976; Deep Lake Farm, Lakeville, Conn.*
Marshall B. Dalton, '15; P.O. Box 156; Peterborough, N.H.*
David P. Rogers, '15; September 4, 1975; 155 Dunnegan Rd., Toronto, M5P 2N8, Canada
Ralph V. Tiffany, '15; March 10, 1976; 100 Hinsdale Ave., Winsted, Conn.
Frederic E. Waters, '15; April 4, 1976; 17 Nicholson St., Marblehead, Mass.*
Philip F. Maher, '17; March, 1976; 170 Centre St., Concord, N.H.*
Harold Sterner, '17; March 12, 1976; 349 East 63rd St., New York, N.Y.
Alfred W. Hough, '19; February 26, 1976; 91 Deer Meadow Lane, Chatham, Mass.
George A. Irwin, '19; February 25, 1976; Box 882, Delray Beach, Fla.*
Adin A. Brown, '20; April 4, 1976; Colonia Miramonte 68, Scottsdale, Ariz.*
Isaac Dougherty, '21; February 21, 1976; 177 Clark St., Hamburg, N.Y.
Robert W. Haskel, '21; March 7, 1976; 8 Grove St., Medfield, Mass.
Edward P. Molloy, '21; March 7, 1976; 880 Lake Shore Dr., Chicago, Ill.
Robert D. Hoffman, '22; December 5, 1975; 151 Central Park W., New York, N.Y.
Warren T. Ferguson, '22; February 24, 1976; 462 Mt. Auburn St., Watertown, Mass.
Julian E. Berla, '23; February, 1976; 1517 26th St. N.W., Washington, D.C.*
C. Arnold Dutton, '23; March 13, 1976; Parkway Apt. 1407, 151 Buffalo Ave., Niagara Falls, N.Y.
John B. Kneip, '23; March 17, 1976; 13701 Alderwood Lane, Seal Beach, Calif.
William E. Otis, '23; September 13, 1973; Box 553, Ligonier, Penn.
Eugene Dhooghe, '24; January 26, 1975
Otto E. Kirchner, '24; February 5, 1976
William R. Franklin, '26; March 31, 1976; 3848 N. Chesterbrook Rd., Arlington, Va.
Robert Wise, '27; April 17, 1976; 328 Kent St., Brookline, Mass.
Hamilton Rumrill, '28; April 4, 1976; Hillsboro, Hillsboro, N.H.
Herbert E. Streeter, '28; January 17, 1976; Arnold Ct., Charlestown, N.H.
Nicolaus Harms, '29; November, 1975; 2121 N. Ocean Blvd., Boca Raton, Fla.
Richard Benson, '30; October 29, 1975; Pine St., Dover, Mass.
Louis H. Flanders, Jr., '33; March 19, 1976; 58 Livingston Cir., Needham, Mass.*
George T. Fisk, '34; January, 1976
Frederick C. Gans, '34; April 4, 1976; 625 West 252 St., Bronx, N.Y.
C. Leslie Grahn, '34; July 25, 1975; 13-A Bennington Lane, Whiting, N.J.
Edwin B. Worthen, '36; March 13, 1976; 35 Dexter Rd., Lexington, Mass.
Robert H. West, '37; March 10, 1976; 834 Oakwood, Wilmette, Ill.
Dimitrios A. Polychrone, '47; January 30, 1976; 62 13th St. N.E., Atlanta, Ga.
H. A. John Green, '54; January 4, 1976; 27 Alexandra Rd., Whitstable, Kent, England
George J. Schulz, '54; January 15, 1976; 37 Old Mill Rd., New Haven, Conn.
Robert R. McMath, '55; December 19, 1975; Rt. #2, Chesnee, S.C.
Robert J. Cattoir, '65; July 13, 1973; 36 Cambridge Dr., Mattawan, N.J.

* Further information in *Class Review*

Class Review

Class of 1903 members at last year's Alumni Day luncheon: (left to right) John J. Nolan, Class Secretary, Mrs. King, and Dr. Robert J. King.

05

Herbert S. Bailey of 1122 N. Euclid Ave., Ontario, Calif., writes that he'll be 96 soon and is practically "housebound." He lives with his daughter and her husband and spends his time "reading, writing letters and playing with my stamp collection which is now worth at least $8,000."

Herman Eisele of 2657 Noble Rd., Cleveland, Ohio, writes, "I have now enjoyed (?) one year of retirement to housework, shopping, cooking, etc. which I found out is a full-time occupation. In addition, I keep busy with a multitude of personal matters like organizing records and keeping my bank balance healthy. Healthwise, I still converse regularly with my medical specialists who do the best they can with what they have to work with. So I am getting by!"

Gilbert Tower is still active in community affairs in Cohasset, Mass. He had published a long letter in the *South Shore News* concerning a law which would put permanent restrictions on the use of salt marshes. Mr. Tower thinks that such a law would have a paralyzing effect on the growth and development of the town of Cohasset.

Please send reports of your activities to the *Review* office. — *S.F.*

06

Henry Mears writes from his longtime home in Portland, Oregon: "**Fay Libbey** and I usually have lunch together on Friday noons, and at that time we meet with state geologists and learn something about plate tectonics and other subjects which were not known in 1906." Thanks for the note, Henry. You are a longtime correspondent and I wish there were many others who wrote to me now and then.

Sam Ware of North Abington, Mass., still keeps going and his career is covered in an article "The Oldest Living Delta," which I will abstract in the next *Review*.

There is one death to report. **Stewart C. Coey,** our Class President, died February 15 at a New Hampshire hospital following a long illness. Stew was born in Leeds, England. He entered M.I.T. in 1902 and graduated with us in 1906, having taken the course in electrical engineering. In the late 1930s he invented Coey Cooling Power and he also developed the first floating floor — used in computer installations to give access to underfloor wiring. Prior to his retirement, Mr. Coey resided in Glenridge, N.J., for over 50 years and made his summer home at Squirrel Island, Maine, where Marion and I visited Stew and Betty — quite a few years ago.

Marion and I keep in circulation — go to church, do shopping, and have nice meals at Wellesley College Club or some other nice place not too far away. We have had no car for several years but our town has a minibus which we use. For well over 30 years Marion has been with a group at church which makes surgical dressings for Boston hospitals and for nearly 18 years I was secretary of the Wellesley Board of Health. — **Edward B. Rowe,** Secretary-Treasurer, 11 Cushing Rd., Wellesley Hills, Mass. 02181

08

There are only 30 graduates of our class living and the average age is 84 years.

We have one change of address to report: **Raymond E. Drake** of Brockton, Mass., to Box 246, Monument Beach, Mass., 02553. — **Joseph W. Wattles III,** Secretary, 26 Bullard Rd., Weston, Mass. 02193

10

We regret to report the death of **Alva B. Court** on February 16, 1976, at his home in Harwood, Md. Although he was listed with our class, probably few of us knew him at M.I.T. since he was a graduate of the U.S. Naval Academy sent to Tech for graduate work. He received the S.M. degree in Course XIII-A (Naval Construction and Engineering). In 1970, when he was a retired captain in the Navy living at Annapolis, Md., he joined us for the 60th Reunion, the first five-year reunion we ever held on the M.I.T. campus. We were happy to have him and sorry to hear, in 1975, that he would not attend our 65th reunion on account of poor health.

Now that we have held the last of our quinquennial reunions it occurs to me to recall a few of the high spots of our reunions during the past two decades. At our 45th at Chatham Bars Inn on Cape Cod, the weather "let us down" on the final day and we had to transfer our clambake from the beach to the dining room. But for a bright spot, **Al Hague** had brought a case of champagne to add to our festivities! For the first time, wines were officially included in the reunion — a custom which has prevailed ever since. Several features of our 50th at the Charterhouse Motel in Waltham come to mind: the excellent group photograph which was taken at poolside, **Larry Hemmenway**'s gift to each of our classmates there of a copy of Professor Sam Prescott's book, *When M.I.T. Was Boston Tech*, and procession in caps and gowns to the stage for the graduation of the Class of 1960. At the 55th Reunion, at the Hotel Continental near the Cambridge Common (in "Harvard Territory"), Professor Charles Stark Draper, former head of the Department of Aeronautics and Astronautics at M.I.T., spoke about gyroscopic equipment designed at the Instrumentation (now Draper) Laboratory in World War II and the even more sophisticated equipment for the control of space flights and moon landings.

Both our 60th and 65th Reunions were held at McCormick Hall on the campus, and we all agreed that this is a luxurious women's dormitory. Attendance at our 60th Reunion was 35, including the wives. Five years later time had taken its toll, and there were only 13 at our "mini" 65th reunion. But enthusiasm was not lacking! Our class is one of the few (perhaps the only one) which has ever scheduled an official 65th Reunion. — **John B. Babcock III,** Secretary, 33 Richardson St., Portland, Maine, 04103

13

Allen Brewer's latest letter included a copy of his write-up in the *N.E. Philatelic Footnotes* which portrays a history of outstanding New England citizens, from the time the Pilgrims landed at Plymouth up to the present day, who have been honored by special issue Postal Service stamps. If anyone is interested, write Allen (P.O. Box 518, Jensen Beach, Fla. 33457).

Allen writes: "It was disturbing to note that **Bill Brewster** was in a nursing home. I have just written him a get-well note enclosing a copy of my latest article in *Philatelic Footnotes*. At one time, when I was doing research pertaining to this subject, he was very sympathetic with the idea and sent me data pertaining to Plymouth Rock and the Pilgrims. . . . Both of us are fine physically."

We are sorry to report the death of **Jack Farwell.** His wife, Jane, writes: "I am sorry to tell you Jack died March 3, 1976, in Boynton Beach. He had a severe heart attack on September 1, 1974 and never regained his full strength — he was such a wonderful

person. He will be sadly missed by me and his host of friends." Jack was born in Natick, Mass., August 16, 1889. He was president of the European Division of the Worthington Pump Co., serving in that capacity for 12 years in France. Following this he became president of the Sperry Corp. and was responsible for the company's moving to Danbury in 1948. He served as president and board chairman until his 1955 retirement. For several years he remained consultant for the company. Mr. Farwell was a member of the University Club of New York and while in France in the 1920s was honored with a life membership of the Union Interalliee.

Also, we regret to announce the death of **Edward Jewett.** We quote the *Boston Herald* of April 1, 1976: "Edward E. Jewett, 85, of Danvers, a retired superintendent of the American Sugar Refinery Co. of Boston, died yesterday in Beverly Hospital. Born in Salem, he attended Norwood schools and was graduated from M.I.T. in 1913. Mr. Jewett had been a resident of Danvers for the past 20 years. He is survived by his wife, Bernice (Atwood); and his daughter, Mrs. Mildred J. Moulton of Norwood."

We hope to see the Class of 1913 together at the Alumni Day luncheon. — **George Philip Capen,** Secretary-Treasurer; **Rosalind R. Capen,** Assistant Secretary, Granite Point Rd., Biddeford, Me. 04005

15

This is a hard column to write. We have had some sad losses. Our Class President, **Jack Dalton** died March 29 in Winter Park, Fla. His summer home was in Peterborough, N.H. President of our Class in undergraduate days, he held that honor ever since our graduation. He was a cheerful and inspiring leader and guided us wisely through many emergencies. He was a devoted alumnus and served on committees and councils of the Institute for 60 years. In 1937 he was President of the Alumni Council. For the past 33 years he had been a member of the M.I.T. Corporation.

Jack was chairman of the first major capital drive conducted by the Institute in its modern history — the Mid-Century Campaign. He also was the first chairman of the Corporation Development Committee. He participated in the present M.I.T. Leadership Campaign as a member of the National Sponsoring Committee. He was an honorary member of the M.I.T. Alumni Advisory Council and in 1975 received a special award from the Corporation Development Committee. Jack also served for 11 years (1952-63) as a member of the Corporation Executive Committee and was on the Corporation Investment Committee and the Corporation Membership Committee during the 1950s and 1960s. He was a member of five different Corporation Visiting Committees from 1934 to 1949. Jack also made major contributions to M.I.T. in the development of the Institute's strong retirement plans for staff and employees. Upon his own retirement, Jack became a Trustee of the M.I.T. Pension Association.

Following his graduation in 1915, he was with Liberty Mutual Insurance Co.; in 1934, he became vice president. He was president of Boston Manufacturers Mutual Insurance Co. and Paper Mill Mutual Insurance Co. from 1934 to 1958, and president of Mutual Boiler and Machinery Insurance Co., from 1937 to 1958. From 1958 to 1965, when he retired, he was chairman of the board of all three companies.

Jack played a major role in developing the Factory Mutual System through which several fire insurance companies join in sponsoring engineering activity in loss prevention, risk evaluation, and risk sharing. He also was a trustee of Northeastern University, Governor Dummer Academy, New England Baptist Hospital, and the Monadnock Community Hospital. He received an honorary doctor of engineering degree from Worcester Polytechnic Institute in 1959, and the Marshall B. Dalton Chair in Religion and Ethics was established in his honor at Governor Dummer Academy in 1969. He was a Fellow of the American Academy of Arts and Sciences.

Carl Wood, who lives in Peterborough, was an usher at the Memorial Services and represented our Class. He wrote, "We shall all miss him with his wisdom and dedication to our Class. He is one of the persons we read about but do not have the privilege to honor." With his annual generous contribution to the Alumni Fund this year Jack wrote to Joyce Brado, our Class Agent: "The way 1915 hangs together is pretty special — isn't it — a great class!"

Another outstanding member of our Class, **Sam Berke,** died April 15 in Lakeville, Conn. Sam and I graduated from the old Mechanic Arts High School in Boston in 1911, so I had known him for a long time. From 1919 to 1936, he pioneered in the manufacture of replacement parts for the automotive industry. In 1936 he organized the old Mr. Boston Distiller Corporation in Boston and for many years was president, retiring in 1970. For more than 30 years he raised cattle on his extensive farm in Lakeville, Conn. He was always a generous and regular contributor to all Class and Alumni activities and will be well remembered by the unusual and attractive gift he gave everyone at our 50th Reunion — a bottle of his fine old Mr. Boston bourbon.

His association with M.I.T. included funding assistance in building of the first language laboratory, establishment of a perpetual award for the best thesis each year in the School for Industrial Management, and membership on the visiting committees for the Departments of Modern Language and of Humanities, the sponsoring committee for the Underwood-Prescott Professorship of Food Services, and the Development Committee. He also was a fellow of the M.I.T. Club of New York City. Sam contributed regularly, and generously, to many public and private funds and charities.

Fred Waters died March 31 in Marblehead, Mass. He had been an outside plant engineer in the Construction and Maintenance division of the New England Telephone Co. He was a past president and a life member of the Telephone Pioneers Club. The sympathy of our Class goes warmly to the families and relatives of these deceased classmates. — **Azel W. Mack,** Secretary, 100 Memorial Dr., Cambridge, Mass. 02142

16

As you read this column our 60th will be history. We will write up the 60th for the July/August issue of the *Review*.

Unfortunately we continue to hear about classmates who have passed away. This week we learned that **Freeman C. Hatch** passed away on April 3 after a lengthy illness. From the news clipping we find that he was a descendant of Captain Freeman Hatch who made the record sail in a clipper, *The Northern Light,* around Cape Horn from west to east. Freeman will be remembered by many as the popular miller, who could be found between 1964 and 1972 at the Eastham (Cape Cod) Windmill, where he told either the history of the mill or whatever imaginative tall story seemed to fit his audience. He served in World War I, was an engineer with J. P. Stevens for 32 years, retiring in 1952, then did some independent engineering work after that and was a registered engineer in Massachusetts.

Last month we reported the death of **Clint Carpenter.** We have taken the following from the news item: He was the founder and principal executive officer of Carpenter Construction Co. for four decades. He stepped down as company president in February, 1974 but remained active as chairman of the board and secretary of the corporation until his recent illness. During his lifetime the firm built bridges, piers, bulkheads, foundations, dams, sewage and water treatment plants, and engaged in soil investigation for foundations. He was a registered professional engineer, member of the American Society of Professional Engineers, a past president of the Engineers' Club of Hampton Roads and a past president of the Virginia Branch Chapter of the Associated General Contractors of America. He was a former director of the Virginia and Norfolk chambers of commerce and the Hampton Roads Maritime Commision. He was a member of Galilee Episcopal Church, a former vestryman and one of the founders of Cavalier Park-Bay Colony Community League of which he was a past president. He was formerly honorary secretary in Tidewater for the Educational Council of M.I.T.

We were pleased to see this news item relating to our deceased classmate **Bill Drummey**: "The 25th Annual Colonel W. Drummey Gold Medal presented by the Boston Kiwanis Club to an individual who has given long service to under-privileged children, will be presented May 20, 1976, to Humberto Cardinal Medeiros." . . . We were hoping to see **Art Shuey** at our 60th but received this response to our invitation: "Sorry I failed to answer your letter of February 3, but we were on a cruise to Hawaii. I suffered an attack of arthritis and next week we are going to Hot Springs, Ark., until I get rid of it." . . . Also this one from **Howard Evans**: "I have moved far away from the Boston area and cannot be counted on to attend any of the Class of 1916 festivities." He is now living in McLean, Va., in a "Residence Foundation" for retired Navy personnel. "I was, and am, a member of the Navy Reserve, Civil Engineers Corps., and had enough duty, both in peace and war, to qualify for admission to this fine 'Residence.' " . . . Nice to hear from **Dan Comiskey.** He noted the passing of Freeman Hatch and said, "I have known him since 1911 in Prep School at Chauncey Hall with **Ken Sully** and others." . . . **Theron Curtis** indicated that he and Hope will bring their two sons and their wives with them to the Clambake at our 60th. . . . We look forward to your

cards and letters. Keep breathing and keep writing. — **Ralph A. Fletcher,** Acting Secretary, West Chelmsford, Mass. 01863

17

Our last Notes called attention to Francis E. Wylie's pictorial history, *M.I.T. in Perspective,* which is replete with references to members of the Class of 1917. Here are some of them: Prominently named is **Edward Pennell Brooks,** first Dean of the Alfred P. Sloan School of Management, who was the first M.I.T. graduate in management. The picture of the good Dean with his successor, Howard W. Johnson, later to be President, is a delightful example of photographic ability to show speaking likenesses and characteristic warm smiles. **Harold Lobdell** is shown as editor of *Technology Review,* and **Edward P. Warner** is noted as taking charge of Aeronautical Engineering, then to become Assistant Secretary of the Navy and finally editor of *Aviation.* **Leslie Groves** headed the Manhattan Project, playing a prominent part in the introduction of the nuclear epoch. **Edwin Aldrin, Sr.,** is credited with constructive contributions through aeronautics to the great war effort, but that is overshadowed by his fathering of one of the first two humans to land on the moon, Buzz Aldrin, '63. **William H. McAdams** wrote the first comprehensive text in *Principles of Chemical Engineering.* One of our chemists, **Robert Mulliken,** became a University of Chicago professor and in 1966 won the Nobel Prize. **James Beattie** was one of a "long line of first-rate chemists" who made important contributions. In chemical engineering, **Walter G. Whitman** conceived the two-film theory of mass transport between phases, widely used in industry and in pollution control. The School of Architecture did not fully enter its modern period until 1944 when **William Wurster** became Dean. M.I.T. practically invented sailing as an intercollegiate sport and has won more championships than any other school, and **Walter C. "Jack" Wood,** who was Sailing Master for 27 years, can be thanked for much of this success. He was the founder of the Intercollegiate Yacht Racing Association and the North America Hall of Fame at Annapolis, to which he and eight other M.I.T. sailors have been elected to membership. The last picture in Wylie's book is that of the M.I.T. Corporation as constituted for the 1974 annual meeting, and at the right end of the front row is **Walter Beadle.** He has served as an active member of the Corporation for 20 years, being involved on many committees.

Every alumnus should find deep interest and satisfaction in Mr. Wylie's history, and most will find they knew only vaguely of the accomplishments of faculty and administrative leaders from our Class in their M.I.T. family.

Ray Brooks replied to a January memo by means of an April phone call. He keeps busy but with strict limitations. . . . Not until this March 17 did **Bob Erb** reach his 79th birthday, being until that time a minority of one in the Class. . . . **Al Litchfield** plans on attending this June's Technology Day and also our 60th next year. He asked how he could obtain one of the red jackets; this information was sent to him and is available to anyone who is interested.

An exhibit of **Nelson Chase**'s water colors and portrait pastels was hung in the Shawmut County Bank in Belmont in April. They covered a variety of subjects — interiors, a home or two, the rotunda of the Museum of Fine Arts, and a splendid self-portrait in color. The snow scenes showed the local winter at its best, but even more appealing were those of the Maine coast with views of sailing and fishing.

On April 6 **Enos Curtin, Clarence Seely,** and **Dick Loengard** met for the monthly lunch at the New York Chemists Club with two '16ers.

Mark your calendars now for our 59th Reunion on October 6, 7, and 8 at Northfield Inn.

Dinner for nine — try to arrange it! That is what was planned so four members of the Class could host four Aldrin Scholarship students and the Director of Student Financial Aid. We finally settled on April 21. One student, Allen Glombiki, '77, was in Chicago scouting possibilities for financial aid for his medical training a year hence. This left students Michael Solis, '78, Paul Lagace, '78, and Owen Knox, '76, available. Owen was last year's Aldrin Scholar; he dropped from sight last summer and mysteriously did not return in the fall for his senior year. He reappeared this winter and will now graduate next fall. Here is what happened: last May he joined the Marines. Why? By the terms of his enlistment he would be able to go on reserve in time to return to M.I.T. in the fall. But because of Angola his regiment was put on standby alert, runway status, weeks before the newspapers broke the U.S.-Angola story. Owen was under wraps. Neither he nor anyone else knew what was to be, so he missed his M.I.T. term. His purpose in joining the Marines was to effect a Navy transfer from his reserve status and gain Navy financing for his space-medico education. Quite a maneuver and it continues in prospect. Dan Langdale, Assistant Director of Student Aid, with **Stan Lane** and **Stan Dunning** completed the group. Regretably **Al Lunn** and **Ray Stevens** could not be present. The conversation never let up. Stories of the past and present got attention, student activities, work, hours, money, athletics, scholarships, aid, M.I.T. all came under discussion. The students are surprised that 1917 could be interested in their work and progress. The dinner and time went well, causing Dan Langdale to comment that, "It was great, never a lull and no generation gap at all." It was a learning session for all of us.

With regrets the death of **Philip Maher** on March 9 at Concord, N.H., is recorded. — **Stanley C. Dunning,** Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard,** Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

18

Your secretary is happy to report a most excellent representation of '18ers at the Alumni Advisory Council meeting on April 5. Our group included Elinor and Prexy **John Kilduff, Julie Avery,** and **Julie Howe.** We were all impressed with the report of the M.I.T. Leadership Campaign as presented by Jerry Wiesner and Howard Johnson. In particular Howard's description of what distinguishes an M.I.T. alumnus struck me as his most important comment: "M.I.T. men understand the dignity of useful work — the need to accomplish something important, a satisfaction of achievement, the habits of success. The all-encompassing characteristic of M.I.T. people is that they return again and again to make something happen that will leave the world a better place."

It is apt that a most welcome letter arrived from **George Brewer** — to prove the correctness of Howard's remarks. When George retired from his job with the American Meter Co. after 33 years "I knew I would have to keep busy or I would go nuts. So, after having absorbed all I could from Professors Talbot, Sherrill, and Lewis, and having squeaked through but never having made use of my chemical engineering, I set up my own little chemical factory in the form of a private winery in my basement. . . . In all I made wine from 31 varieties of grapes, seven kinds of fruit, and other materials — honey, oats, dandelions, etc. Some of the results were awful, but eventually I produced a fairly good product." George is also into ceramics, having made some fine porcelain goblets and mugs. Then he tried the local "blue clay" and went through the whole process — mining the clay, making patterns and molds, casting and firing in a gas-fired kiln of his own design, and finally decorating the finished product. In addition, for ten years he was secretary of the local historical society, retiring only at the end of 1975. In his honor upon retirement, the society made him an honorary member for life — and presented the certificate at an open house with over 200 guests. George says he was "quite overwhelmed." He and Pat have also become "seasoned sailors" — two cruises on inland waters and eight ocean cruises, including Palermo, Algiers, Ecuador, Hawaii, and lots of others. A train trip across Canada is next, in June. "For us retirement has been interesting and a lot of fun," he writes.

A note from **Fred Philbrick** advises us of the death of **Wendell Monroe** on March 25, 1976.

A news item in the *Salem News* advises that **Don Goss** made a bequest in his will to the M.I.T. Alumni Association.

As our number regretfully decreases, news items from all of you are more urgently needed. Please send them. — **Max Seltzer,** Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine,** Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

19

George A. Irwin, Sr., passed away on February 25, 1976, after an extended illness. He was a retired Air Force Colonel. He is survived by his wife of Delray Beach, one son, two daughters, 21 grandchildren, and five great-grandchildren.

J. Elliot Cannell writes from 244 N. Tradewinds Ave., Lauderdale by the Sea, Fla., 33308: "My wife Wanda and I live here in Lauderdale by the Sea for about six months each winter and return to Kennebunkport, Maine, the remaining six months. We are in reasonably good health and manage to get in a little traveling from time to time. I do not have any contact with members of the Class of 1919, except as I hear about a few through my fraternity news." . . . **Ben Bristol** writes, "I am still busy giving out service pins at the company, kicking a golf ball around, attending a mix-

ture of meetings, and just trying to fill family obligations." . . . Word from **W. B. Clark** at 175 Goden St., Belmont, Mass., 02178: "My world collapsed March 1, 1974, when my good wife succumbed to cancer at age 76. Then last July my eldest, aged 47, died of the same disease. Luckily I still have three children, ten grandchildren, and one great-grandson who come often and keep a close track of me. I am still hanging on alone at the old stand. Will soon be driving to Maine for the summer as I have for 50 years or more. No serious health problems of my own."

From Paulsboro, N.J., **George Bond** writes, "I have just returned from a trip to visit my brother and sister near Winter Park, Fla. And next week I shall be going on a trip to Ireland, Scotland, and England for two weeks. Have a grandson in college in Delaware and a granddaughter in college in New Hampshire, plus eight younger grandchildren who keep me real busy. Glad to say I enjoy good health and remain active in scouts, Y.M.C.A., and other community affairs. . . . A card from **Nelson Bond**: "You deserve a vote of thanks from all your classmates for being an excellent class secretary."

Best wishes for a good summer to all. — **E. R. Smoley,** Secretary, 50 East Rd., Apt 11E., Delray Beach, Fla. 33444

20

It is with a heavy heart that I tell you of the passing of **Skeetz Brown** on April 4, at his home, Colonia Miramonte, Scottsdale, Ariz. News of his death was thoughtfully provided by his good neighbors and classmates, **Charlie Klingler** and **"Dusty" Miller.** Skeetz had been in ill health for some years. It prevented him from attending our 55th, which he very much regretted as he had been a faithful attendant at many previous reunions.

After graduation, Skeetz worked at mines in Idaho, Utah, Nevada and California. He returned to Massachusetts in 1922 and did ore dressing research at M.I.T., and also taught underground surveying with the mining engineering students at M.I.T. and the General Electric Miea Mine in Bristol, N.H. He then became associated with American Smelting and Refining Co., where he remained for over 40 years serving as assay chemist, mining engineer, mine superintendent, geologist, general superintendent of operations, assistant manager and general manager of the Mexican mining division. Twenty years ago he transferred to the headquarters office in New York as Vice President and Director, where he took charge of all the company's mining operations throughout the U.S., Canada, Great Britain, Australia and Latin America.

A letter from Skeetz earlier this year tells about his experiences in employing engineers from a number of institutions of applied science, and continuing to be impressed by the excellence of M.I.T.'s preparation. Wrote Skeetz, "It was my good fortune to be in a position to select and recommend a number of our promising young men for Sloan Fellowships. That M.I.T. experience helped each of them to become capable and accomplished executives."

Skeetz is survived by his wife, Margaret, a son and two daughters, and several grandchildren. His loss will be keenly felt by us all. Besides being a most popular and beloved member of the class, he represented the qualities of character and achievement that we like to feel our good class stands for. — **Harold Bugbee,** Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

A delightful letter came from Helga (Mrs. **James) Parsons** in early April: "We're back in Sarasota after a memorable March, beginning with the colorful Fiesta in Mexico City — Jim's fourth, so he received his Eager Beaver award. He was the sole representative for '21 and second in seniority only to that live-wire Texan, Jonathan Noyes, '12. After the four-day post-Fiesta tour, we flew to San Rafael, Calif., to visit one of my daughters. The next scene took place at the San Francisco Airport. After not seeing each other for 55 years, **Grant L. Miner** and James Stewart Parsons staged a pre-arranged mini-reunion, accompanied by wives Marianne and Helga. No four people could have had a more delightful two days than we did. The Miners' Los Altos home is an artistic joy and what varied talents they possess. After a gourmet meal, we'd coax Marianne to the piano and plead for 'more, more.' We did the '17-mile drive,' lunched at Fishermens' Wharf in Monterey — much reminiscing, punctuated with laughter. Being back in the West made it special for me — meeting the Miners made it a gem of an experience."

George Chutter writes that he attended an April luncheon at the Cove Inn at Orleans, Mass., to discuss formation of a Cape Cod M.I.T. Club. Attending also from our class were **Don McGuire** and **Whitney Wetherell.** George reports that the consensus was to start operations with two meetings a year — at noontime and with an M.I.T. speaker. George continues active in church and Gideon affairs, and his wife says he is doing too much.

Alumni fund envelopes have brought in a few morsels: **L. D. Worsham** of La Jolla, Calif., and **George Gokey** of Charleston Heights, S.C., both report good health and enjoyment of life in their warm climates. . . . **Fred Marlow** of Pacific Palisades, Calif., is continuing active in land development, business centers, mobile home parks and home building. . . . **Dayton Brown** of Manhasset, N.Y., says he still goes to his office every day but his son is handling the day-to-day operations of their testing laboratory and sheet metal divisions. . . . **Arnold Davis** of Berkeley Heights, N.J., reports trips this past summer and fall — to Cape Cod in July, Maine in August and September, and Niagara Falls in November. Second Honeymoon?

Willis Bugbee, Jr. of Detroit, Mich., took a Caribbean cruise in December instead of going abroad as he had in each of the past seven years (five times to the Orient and twice to Europe). Said he: "I visited the impressive Maya ruins in Guatemala, Belize, and Yucatan, and noticed some striking similarities to the great Khmer temple ruins at Angkor in Cambodia, which I had visited in 1968." . . . A clipping with a November dateline from the *News* and *Foxboro Times* reports the award of the (Boy Scouts) Silver Beaver to **William A. Collins** of Taunton, Mass., "for distinguished service to boyhood." The citation read in part, "After obtaining an engineering degree at M.I.T. and choosing a career in foreign technological service, he elected suddenly to abandon this plan and was chosen in 1934 to become Annawon Council's second chief executive officer. Until 1961 he served as Council Executive, completing 45 years of volunteer and professional scout service. He commanded the wide-spread respect of New England regional leaders, yet he was modest about personal achievement."

A Fort Worth, Tex., news release states that the Board of Directors of the American Society of Civil Engineers announced the establishment of the "**Simon W. Freese** Environmental Engineering Lecture," endowed by the partners of Simon Wilke Freese, consulting engineers. At about yearly intervals, the Environmental Engineering Div. of A.S.C.E. will invite a distinguished person to prepare for publication and delivery an environmental lecture at a meeting of the A.S.C.E. The lecturer will be given a certificate and an honorarium of $1,000. Simon Freese did graduate work at the University of Cambridge, England, after getting his degree at M.I.T. During his career, he was chief engineer on various major water projects in Texas. During World War II he was a Lieutenant Colonel on the staff of General Eisenhower as economics officer for the military government. The Freeses live in Fort Worth and have two sons and a daughter.

Ted Bossert writes from Pittsburgh: "Shortly after I retired from Alcoa in 1962, I became interested in the activities of the Hunt Botanical Library, part of the Carnegie Mellon University. As a result, I have been donating my time, three days a week, in collecting portraits of botanists. Result — the largest collection of this type in the world." . . . **Norman Insley** writes: "Righting the wrongs in the world, I'm designing an automobile for the average man who is higher than he is wide. There's nothing like this avant garde stuff." . . . **Chesterton Knight** and his wife Marion celebrated their 52nd wedding anniversary last October. They stay at home six months of the year in Brockton, Mass., summer for four months on Martha's Vineyard, and then go south for two winter months at Sanibel, Fla. "Retirement is great. Golf every other day."

A postcard from **George Gokey** tells of their annual trek to St. Maarten in the Caribbean. Another Caribbean visitor was **Irv Jakobson** who did some sailing around the Virgin Islands in early March.

One death was reported this month: **Dana A. Barnes** of Anchorage, Alaska, on June 7, 1975. Dana worked for many years as Bridge Engineer for the Division of Highways in California. The sympathy of the Class is extended to his family. — **Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah Crosby,** Assistant Secretary, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden,** Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

Your Secretary was in South America for part of April with a Buffalo Chamber of Commerce group spreading good will about Buffalo and western New York. . . . **Randall**

E. Spalding of Whitefield, N.H., writes that M.I.T. alumni continue to stop by the Spalding Inn Club, which includes Maude and **George Boli** of Sarasota, Fla.; Marion and **Norman Greene** of Newtown Square, Penn.; Marion and **Percy Bass** of Tequesta, Fla.; Emily and **Laurence Davis** of New York City; Jessie and **Raymond Miskelly** of Yarmouthport, Mass.; and Madeline and **Parke Appel** of Venice, Fla.

The sympathy of the Class is extended to the families of **Julius W. Werra** of Milwaukee, Wisc.; **Irwin J. Smith** of Albany, N.Y.; and **John Ward Poole** of Jaffrey Center, N.H.

As you can see, there are few news items this month. Please keep in touch. — **Whitworth Ferguson,** Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz,** Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

23

We are glad to welcome our active Secretary-Treasurer, **Tom Rounds,** and his wife Marjorie home again after their 25,000 mile trip. "We started in Rio on February 14, then to Buenos Aires, Capetown, Johannesburg, and Nairobi where we started an eight-day motor safari in Kenya and Tanzania. Then on to Addis Ababa, Lalibela and Cairo. Got chased out of Egypt two days ahead of time on account of severe sandstorms. Came home by way of Holland. The two nights in Amsterdam were a blessing after the filth and dirt of Cairo." Tom also reported that although at times the trip was a bit strenuous, he and Marjorie are in good shape and both enjoyed their various, interesting and refreshing experiences.

Alan R. Allen received a letter from Anne J. Valentine saying that her husband, **Allard Mayo Valentine** died in his sleep on January 23, after a long illness (over three years) diagnosed as A.L.S. (the "Lou Gehrig disease"). Al Valentine was an active student at M.I.T. He was a member of the Class Crew, Varsity Crew, wearer of R.T.A. and B.T.C. and 1923 numerals. He was on the hockey, football and wrestling teams, and was a member of the Beaver Club, Chi Phi, and the Civil Engineering Society. In 1937 he joined the Auburndale Cooperative Bank and later became its president. He was a senior member of the Society of Residential Appraisers, Alderman of the City of Newton, senior member of U.S. Power Squadron, Treasurer of the Watertown Yacht Club, and member of the New England Cruising Association.

Philip Schwartz, retired army officer and educator, took courses in Mechanical Engineering at M.I.T. He also attended Columbia University, Princeton University and U.C.L.A., where he is now considered to be the oldest graduate. He believes that the elderly need something to make them feel useful. He says, "Ten years ago I got the idea that old people should go to school. You can't give old people jobs because then young people can't get them." After his retirement from the army, he worked as an engineer for the Lockheed Corp. and then taught at a junior college until his forced retirement in 1961. He is against forced retirement and does not believe that when we reach a certain age we should not work. At 80, he has no job worries, although he isn't sure how much longer he can attend classes. He has paid his fees for this quarter, so "they can't kick me out," and is ever optimistic toward the future.

Edward Frances McSweeney, Jr., Management Consultant, has been named 1975 Graphic Arts Man of the Year and Recipient of the Lewis Memorial Award of the Printing Industries of America. It was presented to Ed on October 6, 1975 in Dallas. It recognizes his service both to industry and to his community. He has won many honors and is the recipient of the Bard College Medal, Elmer Voight Award, Friedman Medal, Golden Keys Award, Life Membership in P.I.A., and the Westchester County Distinguished Service Award. We congratulate him on his achievements.

We are delighted to learn of the marriage of **Ronald D. Brown** to Miss Ethel L. Wright on March 17 in the Chapel of Hancock United Church in Lexington, Mass. The couple will be at home at 27 Edgewood Dr., Lexington, Mass. 02173.

We are sorry to learn of the death of **Julian E. Berla** of Washington, D.C., on February 16, 1976. Julian was born in 1902, prepared at the Central High School of Newark, N.J., and graduated with us with B.S. in architecture. After graduation he established the partnership of Berla and Abel in Washington. He was a fellow of the American Institute of Architects. He participated in the design of the Greenbelt Community near Washington and later designed a number of important buildings in the Capital area including the Van Ness Center, the Farragut Building and the Indiana Building. He was a consultant to the Danish government on public housing, the Washington Board of Trade and the design review board of the Baltimore Housing Department.

Also we are sorry to report the death of **Benjamin P. Bullman** of Yarmouth, Maine, on March 13, 1976. Ben was born in Plainfield, N.J., in 1897. He graduated with us with a degree of B.S. in electrical engineering. After graduation he founded the Massachusetts Heating Corp. He was a Navy veteran of both World Wars. In his retirement years he served actively with the Yarmouth Chamber of Commerce and the annual Yarmouth Clam Festival.

Lastly we sadly report the passing of **Earl C. Palmer** of Port Ritchey, Fla., February 6, 1976. Earl was born in Cincinnati, Ohio, in 1901. He received his B.S. degree with us and later his M.S. degree in chemical engineering in 1924. After varied experience in the fields of lead and copper smelting, water purification and baking he became Assistant Production Manager of the National Biscuit Co., Bread Division, from which he retired in 1966. — **Thomas E. Rounds,** Secretary-Treasurer, 990A Heritage Village, Southbury, Conn. 06488; **James A. Pennypacker,** Assistant Secretary, Long Hill Rd., Essex, Conn. 06426

24

Continuing the Fourth Florida Fiesta from the May issue, a letter from **Cy Duevel** adds **Dick Jackson, Bob Morton** and Betty, and **Paul Miller** and Helen to the attendance list. The group's enthusiasm for get-togethers resulted in a vote to hold the Fifth Florida Fiesta November 13 to 20. Paul and **Gordon Harvey** have arranged a cruise from Ft. Lauderdale to the Caribbean on the U.S.S. *Fairwind.* Rates vary from $435 to $895 per person. For information, contact **Clint Conway,** 805 Maximo Ave., Clearwater, Fla. 33519, or call 813-726-3625. Gordon is very pleased with his doctor's approval to begin a European vacation September 15, visiting many big cities. He and Clare celebrated their 51st anniversary recently.

A letter from **Gordon Billard,** Class Estate Secretary, clearly indicates bequest and trust methods so important to the success of the M.I.T. Leadership Campaign. . . . **Paul Cardinal** complains on the back of an Alumni Fund envelope that it is too small for notes and that the *Review* should resort to the *Wall Street Journal* method to reduce time lapse in Class Notes.

Alexander J. Bone, Associate Professor of Transportation, Emeritus, in Civil Engineering at M.I.T. died March 30, 1976. He was acting head of the Transportation and Surveying Division from 1954 to 1962, retiring in 1967. He was involved in planning the Massachusetts Turnpike, Garden State Parkway, Route 128, and conducted major studies for the Railway Associations of America, Canada and other countries. His economic impact study of Route 128 served as a model for similar studies. Your Secretary, personally, offered the Class sympathy during calling hours, to his wife and family.

The widow of **William F. Behrman** writes of his death on June 19, 1975. He spent over three years at the Institute in chemical engineering and in 1924 began a career in petroleum research with Arthur D. Little, Inc., Cambridge, Mass. In 1949, he was associated with the Tidewater Oil Co. in Bayonne, N.J., and in 1967 retired, living in Westfield, N.J.

Albert B. Donkersley died June 10, 1975 in Providence, R.I. He graduated in electrical engineering, having transferred from Rhode Island State College, then joined the Grinnell Co. in Providence as a student trainee and advanced to chief engineer of the industrial piping division. It appears that he was associated with one of the Grinnell companies until retirement. Bert was an avid golfer and member of the Wannamoisett Country Club in East Providence. The Class extends its condolences to his family.

One of the lesser known feats of our very famous Lt. Gen. **Jimmy Doolittle** has recently been published. He has always been aviation enthusiast, but in 1926, he staged a plane sales demonstration for official military observers at Santiago, Chile. Even though injured in a fall at the officers' club several days previously, with both ankles in casts, his shoes clipped to the rudder controls, he put his borrowed Army Curtiss Hawk through slips, rolls, reverse turns and dives. The Chileans bought the Hawk and he flew across the Andes to continue his sales mission to Argentina. Very few have any real conception of Jimmy's catalogue of accomplishments. Best known for his daring raid on Tokyo to end World War II, he was a war hero in North Africa, Italy, England and Okinawa; an ardent ambassador for air power in the 1920s and 1930s, and the archetype of the pilot who helped bring the airplane to maturity with stunts, races, endurance records and trophies.

As your Secretary was about to mail these notes, a letter from **Walter J. Bagby** brought the sad news of the death of **Joseph R. Mares** on April 13, 1976 at his home in Dickinson, Tex. Walter, **Sox Kinsey** and Joe were close friends. Joe

graduated in chemical engineering, studied law at several schools and joined Monsanto Chemical as its first patent attorney, heading the patent department until 1943. He was general manager of Monsanto's Texas division in 1947 and directed rebuilding of its plant destroyed by the Texas City explosion. Leaving Monsanto as a vice president in 1954, he formed Mares & Groope, petrochemical consultants, which continued until 1974. Joe was active in a wide range of business and civic affairs wherein he will be greatly missed. The sympathy of the Class is extended to his wife, Delia, and family. — **Russell W. Ambach,** Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart,** Co-secretary, 8 Pilgrim Rd., Waban, Mass. 02168

25

Our loyal classmate in Japan, **Masaru "Kamy" Kametani,** writes regarding some of his activities and plans for the summer. Alexander Levine, **Mac Levine**'s son, is expected in Tokyo this spring and Kamy will be ready to entertain him. Later he hopes to come on to Boston to visit the Webster Spring Co., which Mac started. If all works out, Kamy will be in Cambridge for Technology Day. Kamy and his wife, Hisako, expect to visit Europe, possibly in August, to celebrate their golden wedding anniversary.

Henry Sachs writes that Mrs. Bernerd Phillips, his bride since December, has for a number of years been Director of Social Services at the Beth Israel Hospital in Boston, and teaches at the Harvard School of Public Health and at the Graduate Schools of Social Work at Simmons and Smith Colleges. They went abroad for their honeymoon.

Ed Murphy has been making trips on a regular basis each spring and fall for the past several years. On March 10, he took off for Mexico City and Acapulco. He was pleasantly surprised to find M.I.T. so well represented on the flight down; many passengers were on their way to the Club of Mexico City's annual fiesta. Ed had not made reservations for this fine event, but Joe Martori of the Alumni Association came to his rescue. Ed says our president, **Chink Drew,** and Lillian were among the members of our class in attendance. After Easter, Ed went to Florida for a couple of weeks hoping to call on his many friends there. — **F. Leroy (Doc) Foster,** Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

It is Easter Sunday at Pigeon Cove. After a long winter, extended by months when the temperature every morning has been 40°, today is a delight — so much so that I have procrastinated it away trying to find a base for this issue of class notes. But procrastination is pleasant when it includes a visit to the yacht club to observe the annual launching of the Harbor Patrol Boat — with our unrequested advice about swinging it to one side to prevent damage to the propeller — a visit to Ellen's Restaurant at the head of the wharf for morning coffee — a drive to the top of Pigeon Hill with our neighbor's grandchildren to show them the gorgeous view and demonstrate that our CB mobile radio will communicate clearly from that 230-ft. elevation with Rye, N.H., 30 crow-fly miles away. Luncheon of Easter ham and scalloped potatoes on our terrace overlooking the sea and so on into the martini hour. But all the while the background thought has been, "What can we say in an issue of Class Notes that will be in your mailbox right after you return from reunion, but of course cannot report on the reunion?"

A thought has come out of all this procrastination. Let's talk about those who cannot make it to reunion. Some classmates cannot make it because they are no longer around, some cannot for health reasons — there are many good reasons. Having scanned the '26 obituary list from A thru C it is obvious that we can only mention a few. All of us remember the dark cloud at graduation time when **Charlie McCulloch**'s twin brother **Dave** was killed in an elevator accident, a promising career suddenly halted. I'll always remember the effort **Johnny Drum** made to visit Pigeon Cove a few months before his death in the 1950s with never an inkling that he was seriously ill. Other colorful classmates in the A to C part of the alphabet who regularly attended reunions were **"Pop" Constantine, Sid Baylor, Larry Cumming, Charlie Bianchi, Martin Bergen** and **Wilbur Criswell.** Just in the A,B,C section there are 57 names of deceased Class of '26 men. A few others are **"Hump" Barry, Ray Bete, Sid Brooks, "Mac" Bush, Stan Cheney, Leland Cummings, Bill Coker, S. M. Chu, Eugene Chase, Saul Brodsky** and **Ken Bragg.** We have been keeping you informed on losses of classmates currently and this is not an attempt to list all of our departed class members but to give a sampling of those who definitely would have been at reunion had they been around. Since deaths are listed each month in a section of the *Review* that precedes the class notes we shall refer you to that in the future, much as you might refer to such a list in your local newspaper. Occasionally there will be a special write-up that should be of enough interest to publish a newspaper clipping and there is one this month. M.I.T. has turned out a few men of the cloth and here's the story of one.

The Rev. **Malcolm A. MacDuffie,** 73, of Bernard, Maine, principal of MacDuffie School, Springfield, from 1936 to 1940 and son of the school's founder, died February 25. Born in Springfield, he graduated from Technical High School and after finishing at M.I.T. taught English at the Institute while attending Harvard School of Education. He resigned as principal of MacDuffie School in 1940 and enrolled in Bangor, Maine, Theological Seminary, where he received his degree in 1944. He was ordained in Ellsworth Congregational Church that year and subsequently served as minister of four churches in Maine from 1940 to 1966. Then he became pastor of Tremont Larger Parish, Maine, for the last ten years while in semi-retirement. He leaves his wife, Margaret, two sons and two daughters, all of Maine, and 18 grandchildren.

I also recall having frequent correspondence with a classmate priest Monsignor **Arthur J. Riley** but never was fortunate enough to meet him.

But enough reminiscing about our deceased classmates who cannot make it — let's talk about the others. **Fred Balfe**'s wife wrote that Fred had been in a disabling auto accident a year ago so they cannot make it; their address is 827A Heritage Village, Southbury, Conn. (Fred is in a nearby continuing care unit.) A few days later **J. B. (Jack) Wright** wrote that he would not be able to attend because he will be out of the country, and the interesting part of his letter was the address, 823A Heritage Village! I immediately wrote Jack informing him of his next-door '26 neighbor and enclosed Mrs. Balfe's letter. Jack tried to contact Mrs. Balfe by telephone without success before leaving on the extended trip to Africa that will cause him to miss our reunion. Upon his return Jack plans to renew his effort to contact the Balfes.

On a recent visit to Florida we phoned **Willard Vaughan;** he regrets being unable to be at reunion because his wife Billie is unable to travel. . . . We wrote **Roger R. Smith** of Jaffrey, N.H., hoping to get him to reunion, and he has replied (first in 50 years): "I retired from manufacturing eight years ago; was around the house for three weeks, biting my nails, when a friend found that I had had something to do with property. I've hardly been home since. At the moment I have completed the design of a 410-foot reinforced concrete dam for a real estate development so they can flood 165 acres and thereby sell waterfront lots.

"We have three children — a daughter and two sons — all married, and 11 grandchildren. Only our younger son lives near us. In September we will have been married 50 years. Our older son is coming on from Colorado the first week in June with his four — one of whom we have never seen. That will be at the time of the reunion, so I regret to say I shall be unable to come to Cambridge in June."

During a recent phone call Class President **Dave Shepard** asked, "Who was President of the Class during our freshman year?" The question added another name to those who will not be with us — it was **William P. (Bill) Lowell.**

Although we have reported that **Gordon Spear** would not be at the reunion because of illness, a letter from his wife Dorothy arrived yesterday telling of Gordon's death from cancer on April 1. We have written Dorothy and extended the sympathy of the class.

So with this unexpected (on my part) departure from the Class Notes format we are over into Monday morning and about to leave for morning coffee plus fried dough and maple syrup at one of the local churches which makes it necessary to say "Cherrio." — **George Warren Smith,** Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

Spring fever seems to have struck our class. Everyone seems to be too indolent to write about his activities — or, perhaps, busy with the annual migration from winter homes to the North. The entire grist this month is a short note from **Ed Mott,** who says, "Since my wife, Lillian Roberts Mott, died in 1971, I have been working for Planned Parenthood. This is a very worthy charitable organization, and I recommend it as a post-retirement activity."

Your secretary is beginning to think about post-retirement activity. As this is written, at Easter, there is little more than four months to go. I have been up to my ears in confer-

ences with bankers, investment firms, and ratings services to put together a financing package for New Rochelle that will leave the City without major financing problems for two or three years. If it goes over as well as it promises to, I can begin to wind down. I feel as if I shall be looking for some kind of activity after a brief vacation. I hadn't thought of Planned Parenthood before Ed Mott mentioned it. — **Joseph H. Melhado,** Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

We have a most welcome letter from Jo and **Al Gracia** telling us they have returned from their winter stay in the Caribbean and are settling in at their new home in Southbury, Conn. They say: "We are now well established here in Heritage Village and arrived about in time to say farewell to Mary Nichols as she headed back to Massachusetts! But we did get in a good visit before she left. Here in Southbury we are only one hour away from one daughter and three grandchildren. The other daughter and four grandchildren reside in Baltimore — an easy trip by Amtrak. So we are content to be Yankees again after 47 years as Buckeyes. By mid-June we will be off again to Maine for three months — and so the seasons roll, pleasantly, healthfully, but constantly reminding us that they carry with them the weight of years. We are looking forward to '78 with great anticipation as a preparatory milestone toward our 50th wedding anniversary in 1979."

Mary (Mrs. **Arthur A.) Nichols** also has settled into a new home, in Duxbury, Mass., where she is a neighbor to Jan (Mrs. **John) Chamberlain**. . . . **Morris H. Klegerman** retired December 31, 1975, as President and Chief Executive Officer of Alexander Potter Associates, Inc., of New York, a firm of consulting environmental engineers. Morey has been associated with the firm for over 45 years. He started in 1928 as a sanitary engineer, became an associate in 1937, and owner in 1940. Although retired, Morey will continue as a consultant and will remain on the board of directors of Camp Dresser & McKee Inc., of Boston, A.P.A.'s parent firm.

Katherine (Salisbury) Hazen teamed with her husband, Harold, '24, on January 18, 1976, to discuss "Student Life in the Twenties" at one of the Historical Collections series seminars held at the Institute. . . . Noel Solomons, son of our own **Gus Solomons,** has been appointed Assistant Professor of Medicine at the Pritzker School of Medicine, University of Chicago. Noel has been conducting research in clinical nutrition at the Institute of Nutrition of Central America and Panama. He was a participant in the medical relief effort following the recent earthquake disaster in Guatemala. . . . Ruth and **Bob Carder,** Frannie and **Jim Donovan,** Florence and **Walter Smith,** were on hand to represent the Class at the dedication of the new Ralph Landau Chemical Engineering Building on March 5. . . . Our last bit of news from Marie and **George Chatfield** says that Marie is very busy with church and social activities while George keeps well occupied operating his newspapers, broadcasting stations and Muzak agency. . . . **Bill Hurst** is still professionally active as a petroleum engineer and especially enjoys the challenge of working with young men. . . . As for most of the rest of us, **Newt Foster** asks the question: "How did we ever have time to work?!" — **Walter J. Smith,** Secretary, 37 Dix St., Winchester, Mass. 01890

29

A brief note came from **Harold M. Weddle**: "Made our annual trips to Chappaqua, N.Y., and Helena, Mont., to visit our two sons and their families." . . . **Richard E. Bolton** writes: "Since my retirement as senior partner of the architectural firm of Bolton, Ellwood and Aimers in 1970, we have traveled a bit — many visits to England, where our son was working, Greece, Asia Minor, Australia and New Zealand with a stop over in Japan and Hong Kong. This year we intend to visit England and Italy, and take a cruise in the eastern Mediterranean. My only current permanent job is chairman of the architectural and planning commission of Westmount (suburb of Montreal, population 25,000). I am also concerned with architectural education through the Royal Architectural Institute of Canada and the Commonwealth Association of Architects. I garden, sail and shovel snow according to the season. Our eldest granddaughter is nearly 16 and the youngest grandson is not yet a week old. I also paint pictures and I am currently a director of the Heraldry Society of Canada."

John Dreyer writes: "After a year of consulting with the 3M Co., to whom we sold the firm I started, I am finally retired for good. This means that I am back to work for myself doing whatever that I like, which means mainly doing research applying ultrasonics to liquid crystals. We also have been doing quite a bit of travel for pleasure. I realize that these are our golden years and we better make the best of them, and I hope you fellows do too."

J. Gordon Carr writes: "Trying to keep busy as an architect, which is a job in itself. I also do watercolor painting, which I like very much. I have had two one-man exhibitions in 1975, with another coming up soon. It is very satisfying and rewarding to have people like my paintings well enough to acquire them. One of my pictures is included in the 1976 Connecticut Mutual Life calendar." . . . **Isodore Winer** is slowly recovering from a coronary attack in October, 1975. "I am taking life easy," he writes, "just resting comfortably. This has been the worst January in 30 years here in Glens Falls, N.Y." . . . **Roger Sykes** and his wife Mary spend their summers in Lake Sunnapee, N.H., and winters in Key Largo, Fla. They have a mobile home for traveling to and from Florida. Roger helps, now and then, some of the fellows at Bell Telephone Labs with their frequency control and selection problems. "This keeps me awake," he continues, "and also does some good financially. Mary and I are young and healthy and we hope to remain that way. We follow the herds, spending our summers in N.H., and winters in Florida. Any '29ers who are in our area are welcome to drop in for a visit. We are listed in the telephone book."

Steve Dilworth writes: "we are busy in our small way. During the last six months we have visited England, Hawaii and Florida. I have only one problem: my wife, Myn, is planning a world cruise and I probably will compromise and go along with the idea. We both are well and enjoying life and hope that all of you are doing the same." . . . **George J. Meyers, Jr.,** and wife Barbara enjoyed a week with their son Brad and wife Ann at St. Thomas in the Caribbean. They also attended a wedding of Barbara's niece, Patty Hadley, in Cambridge, with a reception in Andover. They spent a week in the White Mountains, climbing mountains and hiking. Barbara is still busy at her real estate business which shows signs of recovery from the recent recession. She and George are very active, playing tennis and other outdoor sports.

I regret to announce the deaths of two of our members, **Alfonso L. Tammaro** on January 15, 1976, and **David Graham** on January 24, 1976. Upon graduation from M.I.T., Mr. Tammaro became associated with the architectural firm of Coolidge, Shepley, Bulfinch and Abbott as a designer until 1931. He became a resident engineer at the First Naval District in Boston from 1931 to 1932; and a construction engineer for the Treasury Department from 1932 to 1938, serving as a project engineer for the federal agency until 1941. He entered the army shortly before Pearl Harbor and rose to the rank of Lieutenant Corporal in the Corps of Engineers. He was the area manager in charge of construction at Badger Ordinance Works in Wisconsin, and in 1943-1944 he was in charge of construction and operations of plants at Detroit and Decatur, Ill., in connection with the Manhattan Project, which developed the atomic bomb. He received the Legion of Merit citation in November, 1945 for work in plant development. In 1947, he became manager of the A.E.C. operations office in Chicago and later became assistant general manager for research and development, in Washington, D.C. He was chairman of the task force responsible for the report, published in January, 1960, on the future role of A.E.C. laboratories. In 1961, he became assistant to the vice president for engineering at Pratt and Whitney Aircraft in East Hartford, Conn. After his retirement in 1965, he returned to Rhode Island and became a member of S.C.O.R.E. He was a member of the American Nuclear Society and the University Club.

David Graham was a partner and the chairman of the finance department of Hornblower and Weeks-Hemphill, Noyes, Inc. at the time of his retirement in 1969. He was a graduate of Queens University, Belfast, Northern Ireland, and came to the U.S. as a Commonwealth Fellow, receiving his masters at M.I.T. in 1929. In 1945, he became treasurer of the West Virginia Pulp and Paper Co. He was named as financial vice president of the Weyerhauser Timber Co., Tacoma, Wash., in 1948. He joined the Standard Oil Co. (Indiana) in 1952 as financial vice president and director and in 1962, he joined Hornblower and Weeks.

Robert Pride and his wife Marion paid a visit to your secretary last April in Ft. Lauderdale. Bob purchased a condominium in North Palm Beach a few years ago, after his retirement from his position as construction engineer with the Bishop Construction Co., dividing his living time between his home in Shrewsbury and Florida. Last spring, however, they sold their home in Shrewsbury and have become permanent residents of Florida. — **Karnig S. Dinjian,** Secretary, 10 Ancient H'way at Plaice Cove, Hampton, N.H. 03842

30

This month we have a number of reports from our Floridian retirees. **Frank Hankins** reports from Fort Pierce that although he is handicapped to some extent with Parkinson's disease, he still manages to play some golf, swim, and sail. The Hankins spend their summers in New Jersey and winters in Fort Pierce. . . . **Charlie Abbott** reports from Sarasota that he has retired but does not give any details. According to my records he was executive Vice President of New England Gas and Electric Systems. He still attends directors meetings but otherwise enjoys the various recreational activities available near the Abbotts' winter home. . . . **Morell (Hijo) Marean** writes from Delray Beach that he continues "to enjoy year round living in Florida with almost daily swims in the clear blue ocean." The Mareans now have seven grandchildren.

Bob Armstrong reports from Highland Beach that he has retired from his position as Senior Vice President of Celanese Corp. and is now a "sculptor's assistant." Bob's wife Jane has acquired a considerable reputation as a sculptor of free-form and animal sculpture. Last October her works were exhibited at the Frank Rehn Gallery in New York and in May, 1976, she had her own show at the Marjorie Parr Gallery in London. Jane has a studio at the Armstrong's summer home in Manchester, Vt., where she works largely in native Vermont marble. If you wish to see an example of her work, one of her sculptures entitled "Stone Poem II" made of green and white Danby, Vt., marble is located in the new Ralph Landau Chemical Engineering Building, room 350.

George Holt retired in 1968 from Bennington College where he was a member of the art faculty. He is now living in Hoosick Falls, N.Y., which is just across the New York State line from the college. He says he operates as a part-time tree farmer. . . . Once again this year **Joe Kania** will accompany the Vancouver Board of Trade on its annual trip abroad. For three and a half weeks he will visit Italy, France, West Germany, and relatives in Vienna, his birthplace. He still goes to the office three to four hours per day and finds it excellent occupational therapy. . . . **Ralph Appleton** retired in 1968 as President of the Good Realty Co., a real estate management company in Columbus, Ohio, where he still lives. . . . **Stan Wells** writes that he remarried in 1974 and is still living in Rochester. He retired from Kodak in 1973.

We have a notice at hand concerning the death of **Warren Martell** in Long Beach, Calif., on January 16, 1976. In 1963, he reported that he had recently retired and moved from La Grange, Ill., to Long Beach. His activities at that time included controller of the Mohavi Marsh Reclamation Authority and concert master of the Blue Pacific Duo Ensemble. He was also active in fund raising for M.I.T. — **Gordon K. Lister,** Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

There has been a great scarcity of news from our classmates and, unfortunately, your Class Secretaries can't do much about it unless we hear from you. **Parker Dunn** writes that since retirement last September, Mayde and he have enjoyed a trip to the South Pacific last fall and one to the Caribbean in March. . . . **Charley Wood** phoned the other evening and we had a long talk. He is still single, keeping well and expects to be at the 45th Reunion. . . . Sally and I spent a very pleasant evening and dinner at Hope and **Randy Binner**'s recently. They are both still active curlers and travel all over the country in competitions with other clubs. Randy and Hope will also be at the Reunion.

Two deaths of our classmates have been reported since the last Class Notes. According to a newsclipping, **Marshall E. Andelman** passed away on January 2, 1975; and **Charles Martel** died on January 11, 1976. Our sincere sympathy to their families. — **Edwin S. Worden,** Secretary, 35 Minute Man Hill, Westport, Conn. 06880; Assistant Secretaries: **Ben W. Steverman,** 260 Morrison Dr., Pittsburgh, Penn. 15216; **John W. Swanton,** 27 George St., Newton, Mass. 02158

32

John W. Leslie has received this year's New England Award. The March issue of the *New England Engineering Journal* carries a feature story of John's 43-year professional career in government service. The New England Award is given annually "to a living engineer, resident of New England, who by outstanding achievement merits recognition of his accomplished works, as well as his character, by his fellow engineers of the New England States." John began his career with two years as Assistant City Engineer with the City of Somerville, and spent one year with the Geological Survey as a junior topographic engineer. He joined the Boston District of the Corps of Engineers in August of 1936 and has been with that organization (later called the New England Division) ever since. For the past 20 years he has been Chief of Engineering, Chief Planning and Engineering Division. John has been honored twice by the Department of the Army: in 1960 by the Chief of Engineers for Meritorious Civilian Service and in 1972 by the Secretary of the Army with a decoration for exceptional civilian service, the highest civilian award given. He was also awarded the Hydraulics Section Award for the Boston Society of Civil Engineers for his paper on the Hopkinton-Everett Flood Control Project. He is a member of the Boston Society of Civil Engineers; Permanent International Association of Navigation Congresses; Congress of Large dams; Society of Military Engineers and serves as a member of the corporation of the Lawrence Memorial Hospital in Medford, Mass., and was a voluntary advisor to the City Manager on the new Medford High School.

Frank Cook in recent years has been surveying business possibilities in Central America and Mexico and also spent a long summer in East and West Europe. He is now enrolled in the Graduate School of Social Science at the University of California. According to Frank "my burning interest is the very rapid population growth of the 3 billion people in the so-called developing world and the problem of putting numbers onto the real policy problems this growth presents to the western world. I'd be happy to learn of others interested in this problem

Randy Binner, '31, and Hope in their home

area and to correspond and exchange ideas and information with them. All best to you all." Frank's latest address is 42-835 Connecticut St., Palm Desert, Calif. 92260.

And now a very sad duty to report the deaths of **Edward S. Clark,** March 18, 1975; **Peter Laban,** September 9, 1975; and **Dwight S. Ashley,** October 19, 1975. Our sincere sympathy is extended to their respective relatives and friends. — **John W. Flatley,** Secretary, Apt. #204 — 5100 Dorset Ave., Chevy Chase, Md. 20015

33

Top billing has to be the April 5 meeting of the Alumni Advisory Council. We have had few such meetings attended as well. Our class was well represented by **Jim Turner, Westy Westaway, John Long, Bill Barbour,** and myself. Three speakers talked to us about the five-year plan of the $225 million M.I.T. Fund Drive. I came away with the conviction that our school is in the finest of hands.

For the second year in a row, the Mexico City Club Fiesta did not do so well, and hence, by default, the 1933 Mini-Reunion also was somewhat of a disappointment. However, word from our fellas that did attend tells the same story that I have been telling all the time. **Joel Stevens** says, "Elizabeth and I enjoyed the Fiesta, and the Post Fiesta tour. We drove all the way from Tennessee and enjoyed that, too. Highlights were, of course, the 1933 dinner and Nish Cornish's Noche Mexicana." Joel retired October, 1975. . . . **Ellery Clark** thinks the high points of the Fiesta were climbing the Tenango del Valle Pyramids, and Nish and Luisa's Noche. . . . **Bill Baur** says: "The small 1933 dinner was just great; far better for any one person than a much larger one." I must thank Bill for all the work he put into our Mini attempt. . . . **Fred Ladd,** who now lives in Florida most of the year, adds, "Our best day was the Flower Boats Bazaar, and Nish's home." I do not know just what the Flower Boat item is, but, it could be the Xochimilico Floating Gardens, which I have not seen since 1946.

I had a fine note from **Otto Putnam,** and can't find it, and am mortified, as it was from one of the nicest men in the class. However, Otto said about the same as all the others. He could not take in the Post Fiesta Tour as he had to return home on account of family illness. Most of the '33ers attending were from Course II. . . . **Mal Mayer** sent me a card from some place in Chili, where he was enroute to Easter Island. I am convinced

that this fella is not selling beer, or the like! He just can't stay home. . . . **Bob Forbes** writes because I made a mistake. No, Bob, I didn't. **Art Hungerford** sent me a photo of our 20th. Among others, he identified you in the picture. Now, Bob says that he was not there, so it is Art's mistake, not mine: not unusual, mistakes get more response than facts. Bob says that he attends many national crafts shows, via his camper, and he uses it also for pleasure and family trips. He intends to go to L.A. soon, to see his son, and family, where he has two grandchildren. His daughter lives in Memphis. She has three children, two in Memphis State. Bob has always been active in the national organization for barber shop quartets since he was an old Glee Clubber. He has worked his way up in Barber Shop to an application for training, and certification as a Secretary to the Judging Panel, which I assume to be national.

James P. Stewart, who majored in mathematics, passed on in January.

Ellis Littmann, told me that my long, long time friend, **Louis H. Flanders, Jr.,** passed away, of a heart attack. It would be hard to describe my feelings when I heard that Lou had passed. He was a Techtonian as a student, and I was a Glee Clubber, so we got to go to the same concerts many, many times, and my association with him has continued, spasmodically, ever since. To most of Lou's classmates, he will be remembered, mostly, as Master of Ceremonies at many of our class reunions, at which he was a natural.

If I am in order in talking about a subject that is avoided far too often, I wish to ask classmate readers and their wives to keep in mind that both the class secretary and the Alumni Association, ought to be notified just as soon as possible when one or the other has passed on. This is not too much to ask, and I do plead with all '33ers and wives. If only one letter is involved, send it to me, and I, in turn, will notify Cambridge. The Alumni Records group just has to have this sort of information, as they have to publish the Alumni Register, which is, in effect, both a present index of Alumni, and also our Alumni History. History is not much more than a composite biography of great men, and our class had had, and still has, great men. Please keep us informed. — **Warren J. Henderson,** Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

34

The following items are almost entirely from Alumni Fund notes:

Theodore Steinberg, M.D., J.D., F.A.C.S., notes that he is practicing ophthalmology in Fresno, Calif., and in December, 1975, was the President-Elect of the American Association of Ophthalmology. . . . **Al Talbot** is apparently only letting go by degrees. He writes, "Since retiring as a Vice President of Howmet Corp., I have been on three interesting projects for the International Executive Service Corps: a proposed tungsten carbide sintering plant in Mexico, an investment casting plant in Taiwan, and a mini steel mill in Guatemala." If Al enjoys traveling as much as I do, I hope each of these required an on-site inspection. . . . Another retired classmate is **Albert L. Schulerud** who retired after 40 years with Colgate-Palmolive Co. on May 1, 1974. He is "still working about 20 per cent as a chemical engineering consultant on soap processes. The rest of my time is spent in golfing, bowling, singing, traveling, and home and car repairs."

Frankie Moore is still at it. He notes, "Have now become a grandfather for the second time. I have completed the electrification of the Reading Railroad from Hatboro to Warminster (1.8 miles) and am now working on a relocation of the Western Maryland-Chessie System — about ten miles for the Bloomington Dam project." Thinking back to Frank's plaintive remarks of a couple of years ago about how the stock market was cramping his style, I hope its behavior since the first of the year has made life seem better.

Going back to the ranks of the retired, **Harold Leighton** just says, "I am leading a life of leisure in retirement." . . . **Gordon Burns** is more voluble — he writes, "Last May 1 I retired from Bell Laboratories and have been putting in a good deal of my time since then into my sideline business of manufacturing and selling a lightweight swim float or raft, made of fiberglass and foam plastic, for families that have lakeshore cottages. Dot and I have also bought a travel trailer and baptized it with jaunts this fall through New England and New York." . . . From Ocean City, N.J., **Everett Pierce** notes, "Retired. Senior Warden, Holy Trinity Episcopal Church, Ocean City, N.J. Active in Absecon Island Power Squadron."

Mention of the Power Squadron reminds me that I would express our sympathy to **Bill Ball, Jr.,** on the death of his father, a member of the class of 1905. I heard of it because Bill, Sr., had been a past Commander of the Cape Cod Squadron.

Walter Bird sends a very "up-beat" note. He says, "My company, Birdair Structures, Inc., is celebrating its 20th anniversary this year. When I started the company to promote the use of air supported structures for commercial as well as radomes and other military applications which I had developed, I proposed their use to enclose large sports areas and stadiums. It took 20 years to achieve my goal, but last year we provided the roof for the Pontiac stadium — with 80,000 seats the largest enclosed stadium in the world. I hope to build many more."

A final item — **Mrs. Clinton A. Hoar** writes that her daughter Phyllis received a Ph.D. in chemistry last June from the University of Washington. If I read my *Alumni Register* correctly, we would have known Mrs. Hoar as Evelyn Killam when we were in school. — **Robert M. Franklin,** Secretary, Satucket Rd., P.O. Box 1147, Brewster, Mass. 02631; **George G. Bull,** Assistant Secretary, 4961 Allan Rd., Washington, D.C. 20016

35

Our Class has two new Vice Presidents: **Ed Taubman** for the Middle East Coast and **Charlie Piper** for the West Coast. In addition, **Hal Bemis** is going to take over the responsibilities of Special Gifts Chairman. Ed and Charlie join **Charles Debes,** Vice President-Middle West and **Ned Collins,** Vice President-Northeast. Ned will have able assistance from **Don Gittens,** his liaison for Long Island '35ers. You will all be happy to know the Class Treasury is holding its own; **Randy Antonsen** reports over $2,100 in the bank, which will be decreased by the cost of the alumni directory.

Lou Pflanz writes, "Gloria and I enjoyed ourselves immensely at the 40th reunion, in spite of the fact that I had a very severe kidney stone attack the day we arrived. But thanks to her nursing skills, a pill or two that Don Gittens (a former kidney stone 'enthusiast') contributed in the sudden emergency, and a cooperative M.I.T. doctor, I was able to attend all functions at least part of the time. When a few people observed our sudden disappearance from some of the functions, they accused us new lovebirds of wanting to be alone. But it was for me to take to bed and rest! The day after we arrived home I entered the hospital for an ultimately successful 'roto-rooter' job. In August, I was well enough to tow the biggest U-haul trailer from New Jersey to New Mexico to help my oldest daughter get settled in her new rented house and her position teaching chemistry in a Las Cruces high school. After a tour of the southwest, we stopped en route home at Fort Collins, Colo., where our younger daughter is a senior at Colorado State. No longer do I refer to myself as a retired army officer or a 'house-husband.' My new title is 'domestic engineer' — it is more fitting for an M.I.T. graduate, don't you think?"

When we were undergraduates, Course VI was not all that large a group. I think there were only 40-odd B.S. degrees granted in 1935. So it is especially sad when we lose classmates who were members of the electrical engineering group. A daughter of **John "Frank" Keefe** notified us of her father's death on February 26 at Cardinal Cushing General Hospital. He worked as traffic manager in the Boston office of the Penn Central Railroad for 38 years. He lived in Holbrook for 30 years with his wife, Camilla; they had two sons, three daughters and two grandchildren. Frank was a member of the Democratic Town Committee.

Elizabeth Ware wrote of the death of **Perry H. Ware** on January 29 in Pittsburgh. Her letter continues: "At the time of his death, he was Manager of Insulated Conductor Engineering for Alcoa Conductor Products Co. Before he joined Alcoa in 1969, he was manager of Power Systems Engineering for Simplex Wire & Cable Co., Cambridge. He held many positions in I.E.E.E. during his career. He was a past Chairman of the Boston Section, past Chairman of the Insulated Conductor Committee, and at the time of his death he was the 1976 executive Chairman of the Underground Transmission and Distribution Conference. In 1969 he was elected to the grade of Fellow in the I.E.E.E." He is survived by his wife Elizabeth, a daughter, a son, a brother (Hollis F. Ware, '25), and two grandchildren.

On behalf of all their 1935 classmates, I extend our deepest sympathy to the surviving members of Frank Keefe's and Perry Ware's families.

It's mid-April and Boston has just been through a third day of record high temperatures; I haven't even taken off my snow tires yet. This is the kind of weather to start you thinking of cleaning up the yard, getting the screens on, and *golf*. We know as we look at that 96° temperature reading at 2 p.m. today that we'll be trudging the fairways in June in our thermal underwear, and that's what makes us different from Californians.

I hope you are coming to our mini-reunion on June 4. If you are not coming, please write because I would like to hear from you and I am sure others would also. — **Allan Q. Mowatt,** Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

37

Al Woll has recently been appointed to a four year term on the board of trustees of Indiana State University. . . . **Martin Garrott** joined our growing rank of retirees as of February 1, 1976. . . . **Bill Burnet** writes that he is still kicking around despite polio and a heart attack. He has three married children and one daughter in business in New York City, and seven grandchildren. Bill has his own manufacturer's representative machinery company and some young fellows to do the hard work. . . . **Art Zimmerman** sent me an article about **Joe Keithley.** Joe has recently been honored by his colleagues, for his contributions to the electronics industry and for being a founder of the Cleveland Electronic Conference, by being awarded the 1976 medal of achievement during CECON's 23rd annual conference. Joe is Chairman of Keithley Instruments, Inc. — **Robert H. Thorson,** Secretary, 506 Riverside Ave., Medford, 02155; **Lester M. Klashman,** Assistant Secretary, 98 Maple St., Malden, Mass.

38

Regretfully, I must report the death of one of the most colorful members of the class, my old friend **Johnny Cook.** Johnny ran a class reunion. He had been involved with Cornish Wire and Warren Wire Co. and eventually sold out to General Cable Corp. Johnny always went first class. He was killed in the course of piloting his own aircraft.

Another death to report is that of **Victor P. Starr.** He was working on his masters while the rest of us were worrying about bachelor degrees. Dr. Starr spent 27 years on the M.I.T. faculty as professor of meteorology.

Bad things always run in threes. I received extremely late notice that **Hank J. Sieradzki** passed away last year. No further details are available.

The class traveling salesman, **Don Severance,** reports that he has had some contact with **Bill Whitmore** while Bill was in for the M.I.T. Visiting Committee on Mathematics. On one of Don's trips he visited Central Research Laboratories in Redwing, Minn., and spent some time with **Demetrius Jelatis.** Demetrius is Vice President of the company, which was formed to manufacture robot devices for remote handling of radioactive materials.

Welcome W. Bender is President of Custom Engineering, Inc. Welcome had been former project scientist for the Viking Mars space program. . . . **Haskell R. Gordon** has again distinguished himself by being elected a fellow of Brandeis University. . . . **Frank Hagerty,** the old furniture maker — "Cohasset Colonials" — is probably about to seize Route 28 in the Blue Hills. While going through a box of old papers which he had purchased at an auction, he found a stock certificate representing 80 per cent of the Blue Hill Turnkpike Road Co. The only problem: if he wants to take title of the property, he may have to pay the back taxes.

A personal note from your secretary: My son, Bob, Class of 1967, and his wife Lynn, Class of 1968, presented me with a granddaughter, Nicole, last year. Since neither the secretary of the Class of 1967 nor the secretary of the Class of 1968 bothered to pick up this earthshaking event, I thought I would. We are making a tentative application for Nicole for the Class of 1997. — **A. L. Bruneau, Jr.,** Secretary, Hurdman and Cranstoun, 140 Broadway, New York, N.Y. 10005

39

James S. Bruce was appointed Vice President and Director of Corporate Relations at Eastman Kodak Co. . . . **Frank Leonard** has developed an interest in UFO's and would be interested in hearing from those who have the same interest. Frank's address is 1546 Hayes Ave., Salt Lake City, Utah. . . . **Stu Arnold** continues his work on aircraft materials and mechanical research at Watertown, Mass.

Today at Easter Service the minister's points were: we don't know what is going to happen or when; most of us procrastinate in thinking about final outcome topics anyway; when the time for passing becomes known, we all find there isn't time enough left to cover what we want to still get done.

This afternoon, as I was jogging around my hilltop, I thought about the minister's points and about Fred Lehmann and Ken Brock who recently visited California on Alumni Association business. They mentioned that three '39ers did not wait for our traditional 40th Reunion Gift timing and they already made their responses to M.I.T.'s great Leadership Campaign. One bequeathed his entire estate. Another gave in the high six figures, and the third gave in the high five figures. It seemed to me that it is not too soon for the rest of us to discuss this topic with our "better halves," to evaluate what M.I.T. has enabled each of us to achieve, and to determine promptly what each of us will do to enable M.I.T. to carry on our traditions and objectives.

Classmates who need advice with respect to tax and other advantages for their significant givings may call **Fred Schaller,** (617)-235-6015. And if Fred should answer your questions about future unknowns, just drop me a line for inclusion in these notes. — **Hal Seykota,** Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

40

Alumni Register: The 1975 edition of the register probably isn't reading favored for a cozy evening by the open fire, but it is useful and full of facts. For instance, two-thirds of the alumni living in the U.S. reside in the northern tier of states from Chicago to Boston. One-sixth live in the South, Central, and Atlantic coast regions, and another sixth live in the West. Our list of 1940 graduates shows a similar distribution.

Five-Year Reunions: Our class had its 35th reunion on Cape Cod. Where should our 40th be held?

On campus? The old sod in Cambridge probably has the strongest tug on our hearts. But if off-campus, should it be held in just one place? Distance does have an effect on attendance. Distribution of alumni suggests that if an off-campus site were chosen, that one on the east coast is far from the center of gravity. Would, for example, two or three regionally selected sites better serve the nostalgic gathering of more classmates? How about San Francisco, New Orleans and Niagara Falls? Or Los Angeles, Chicago and Atlanta?

Letter from home: **Leo Pach** tells us he came to M.I.T. as a transfer student from Austria in June of 1939. Way back then, his bike riding was an unusual sight on campus. After graduation, he worked as an engineer and then served in the U.S. Army, including duty in his occupied homeland. Out of the army, he was determined to work for peace in response to the loss of friends and relatives in concentration camps or as soldiers on both sides. From 1955 to 1970, Leo taught engineering subjects at several schools including Cooper Union, C.C.N.Y., and Bronx High School of Science. In industry since then, he has been working on piping and turbine analysis for Public Service Electric and Gas Co. He lives in Upper Montclair, N.J., with his wife, Angelina. "Angie is a good painter, homemaker, and gardener. My own home interests and hobbies are peace, disarmament, music, and astronomy. My permanent mailing address is P.O. Box 137, Grand Central P.O., New York, N.Y. 10017. I would like to hear from former classmates, as well as from my former students."

In memory: We are sorry to report Mary A. Higgins' message that her husband, **Arthur T. Higgins,** formerly of Ardsley, N.Y., passed away July 30, 1975, in Escondido, Calif.

Random roll call: Does one of these names ring a bell? **John J. Dineen,** Durham, N.H.; **Halvor T. Strandrud,** Seattle, Wash.; **M. Arnold Copeland,** Allentown, Penn.; **John P. Szumski,** Marblehead, Mass.; **Barrett L. Taft,** Maitland, Fla.; **Thomas P. Bowman,** New York, N.Y.; **Judson M. Rogers,** Mundelein, Ill.; **Nathan Sherman,** Sudbury, Mass.; **Frank W. Defelice,** West Palm Beach, Fla. — **Frank A. Yett,** Secretary, P.O. Box 562, Long Beach, Wash. 98631

41

News of retirements seems to be the order of the day, and I wonder why. Could it be we are getting to that stage in life?

Bob Lundberg writes: "Very happily retired for one year already . . . spent most of last spring, summer, and fall cruising and racing my 30 ft. sloop and much of winter looking at the silver that a good crew won (lots of it) on Long Island Sound out of Larchmont Yacht Club . . . trying now to catch up on reading, painting (watercolor), photography and other projects that have been piling up for the past 30 years."

George C. Newton, Jr., Professor of Electrical Engineering at M.I.T., has relinquished his position as Executive Officer of the Department — M.I.T.'s largest with 1,277 students. Professor Newton, a member of the faculty since 1949, is the author of a number of technical papers and a book in the field of control. He has more than a dozen issued and pending patents on control systems and devices, and has taught both undergraduate and graduate courses in electrical engineering. Prior to his appointment as executive officer, he

was associate director of the Electronic Systems Laboratory. He has acted as a consultant for a number of industrial organizations. Professor Newton was active in planning the sixth world congress of the International Federation of Automatic Control held at M.I.T. last August. His energy research includes work on the energy aspects of consumer appliances and energy utilization in transportation.

Remember our 35th Reunion. I hope to see you there. — **Henry Avery,** Secretary, U.S.S. Chemicals, 2863 — 600 Grant St., Pittsburgh, Penn. 15230

44

John Woolston writes: "In November we left Teheran, Iran, to move to Bandar Abbas where I am Head of the Shipyard Advisory Group and Advisor to the Shipyard Commander of the Imperial Iranian Naval Shipyard, Bandar Abbas. My wife Laura is Head of Personnel Administration. We both are employed by Stanwick International, Inc. It is a great challenge, but we work with great people as we invent a new shipyard." . . . The *Boston Globe* recently carried an article on the growth of microwave units used in foundries and in the food processing and rubber industries as a means of conserving energy in heat processing operations. **Palmer Derby,** now a vice president in the Microwave and Power Tube Division of Raytheon, over 30 years ago witnessed a demonstration of microwave cooking by its inventor, the late Percy L. Spencer, one of the Raytheon's first employees.

Instead of sending each of you a letter, we're using this column to ask you to write to us. For the best write-in we have a class of '44 tray for a prize. (Any information given us during the upcoming alumni telephone campaign or on the envelope with your contribution to the Alumni Fund also counts.)

We welcome any Class of '44 attendees at Alumni Day activities at M.I.T. on Friday, June 4, to our home in Newton between 6 and 7 p.m. for cocktails and conversation. — **Newton A. Teixeira,** Secretary, 92 Webster Park, West Newton, Mass. 02165

47

We are just about to leave for a week of golf and tennis at Hilton Head so these notes will be very brief due to a shortage of both time and material.

A sad note in that **Lester Lechter** of Sharon, Mass., died in January after a long illness. He had his own architectural firm in Dedham.

Bob Whorf writes that he has recently formed Robert Whorf and Associates, specializing in policy research, technology assessment and strategic planning in the areas of transportation, energy systems, environmental impacts and resource management. He is located in the Philadelphia area.

Have a pleasant summer and drop us a line. — **Dick O'Donnell,** Secretary, 28516 Lincoln, Bay Village, Ohio 44140

48

Dave Cist is a consultant in the engineering department of E. I. duPont de Nemours. Dave's specialty is instrumentation for use in automatic inspection systems. Examples are systems to inspect the linear density of a yarn or to detect flaws in plastic pipe. Dave is based in Wilmington, but he regularly travels to other locations. At the end of March, Dave, his wife, and their four children had a skiing vacation. They are also active in photography. The four children went to local schools and now Dave's oldest daughter is trying to select a college.

Bill Katz celebrated 16 years of happy marriage on Friday, February 13. Bill and his wife took their four children to Martha's Vineyard for a great honeymoon. Bill travels to Europe quite a lot. In March Bill attended the Chemical Engineers Convention at M.I.T. . . . **Ben Brettler** is a freshman at Boston College Law School. . . . **Jim Adelstein** is on a sabbatical in Italy. He is working in nuclear medicine at Lucca near Pisa. . . . **Dennis Allegretti**'s son is a student at M.I.T.

Bill Weisz is a new member of the M.I.T. Corporation, for a five-year term. Bill is president and chief operating officer of Motorola, Inc., Fellow of the Institute of Electrical and Electronic Engineers, and a member of Electronic Industries Association (Board of Governors). Bill has served on the Corporation's Development Committee since 1970 and is a member of the Sloan School visiting committee.

Lewis Blodgett wrote that he is still active as an assistant scoutmaster of Troop 8, in Asheville, N.C. Two of his sons are members. His oldest son Lew made Eagle before going to North Carolina State University at Raleigh in forestry. Lewis is active in the Biltomore Lions Club, and the Carolina Mountain Club. Lewis' wife, Jane, is a Girl Scout troop leader; their daughter is a member. . . . **Harvey Taylor** is manager of the Air to Surface Missile Lab of Hughes Aircraft Co. Harvey finally got married in May, 1974, and is residing with his wife, Linda, in Los Angeles. . . . **Ken Bushway** has joined Wyrough and Loser, Inc. as Manager of Technical Services at their Trenton, N.J., headquarters. Ken had been with B. F. Goodrich for 25 years with responsibility for technical management of a variety of products. Ken's new employer manufactures chemicals for use in rubber processing.

John Kearney has been appointed manager of melting services in the Manufacturing and Engineering Division of Corning Glass Works. John joined Corning in 1948 and since 1973 has been supervisor of large tank operations. . . . **Harry Doyle** has been named regional manager for the Denver office of McGraw-Hill Publications. Harry was an executive vice president with Buchem Advertising before joining McGraw-Hill in 1971. . . . **Stan Palmer,** plant engineer at Colby College, has been appointed to the Energy Conservation Committee (E.C.C.) of The Association of Physical Plant Administrators of Universities and Colleges. Stan became plant engineer at Colby in 1972, after serving seven years as superintendent of mechanical services at M.I.T. In the fall of 1973, Stan instituted an energy conservation program which cut Colby's total energy consumption by 25 per cent in 1973-74, and by 20 per cent in 1974-75.

Phil Bragar has left his job at MITRE Corp., (he was Associate Director of Administrative Operations) to move to Israel.

Kenneth C. Bushway, '48

Robert H. Welsh, '48

He explained in an interview published in MITRE's newsletter that "until World War II, I had never been aware of the kind of discrimination against Jews that would lead to their annihilation as happened in Germany. My political awakening occurred the day my unit helped free Dachau, one of the German concentration camps that exterminated thousands of European Jews, as well as countless Catholic and Protestant dissidents." Phil also said, "I'm not going to Israel because I 'got religion' but to help prevent those events from happening again." Phil is a widower and his married daughter lives in South America with her family. He is not giving up his American citizenship.

Jay Lathrop has been elected a fellow of the I.E.E.E. . . . **John Crane** is President of the Chicago chapter of the Illinois Society of Professional Engineers. . . . **Robert Welsh** has been named to the newly-created position of executive vice president of Ludlow Corporation. Robert has been senior vice president since 1973 and has spent his entire career with the company. — **S. Martin Billet,** Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49

A. W. (Andy) Bigus writes: "Our class might be interested to know that **Bob Galvez,** besides being Ambassador from Honduras to the U.S. and Canada, is now also Ambassador to the Organization of American States" . . . Andy himself has "an article in the November/December, 1975, *Package Development,* 'How to Reduce Defective Carton Production in Packaging Lines,' (this should be of wide ranging interest, shouldn't it?)."

A previous letter from Andy enclosed his article in the December, 1973, *Esquire*: "Whatever Happened to Mutual Funds?" "I wonder if anyone would be interested in these findings?" he asks. "(1) Over the past 40 years, mutual funds have not done better than the stock averages in general. (2) Since 1965 the funds overall have made but 2.5 per cent per year for the investor! (3) But, according to three studies, 85 per cent of the investors lose when they play the stock market on their own! (4) So, the best bet for the investor is to shun mutual funds, and, unless thoroughly familiar with security analysis, to avoid the stock market also. (5) What should he invest in? Savings bank accounts, treasury bills, or short-term high grade bonds at yields of six to eight per cent per year."

From Union Carbide in South Charleston, W.Va., an announcement that **Tom Higgins** has been appointed a principal staff engineer in the Engineering Department of the Technical Center. A 25-year employee, he started at the South Charleston Plant. He is presently engaged in long-range planning in the Energy Systems area. . . . **Morse H. Klubock** has moved up from chief engineer to become manager, marine division, of Perini Corp. After graduating in civil engineering, Morse took doctoral studies, at both M.I.T. and Harvard, in engineering, geology and soil mechanics, finishing in 1953. After a brief stint in design engineering, he worked in the Boston office of Merritt, Chapman & Scott, joining Perini in 1957 as project engineer at the Fore River Shipbuilding Ways, built for Bethlehem Steel Corp. in Quincy. Since then, he has been involved with all marine-division projects.

Finally, from Peggy and **Jack Fogarty,** Eric and Barbie: "We discovered garage sales this summer . . . an efficient and fun kind of recycling . . . even had one ourselves . . . but it didn't make a dent in our squirrel's nest. We don't bash bottles anymore but we do recycle our newspapers and trash. Jack installed a sheet metal woodstove in our cellar — a free B.t.u. is a B.t.u. not bought from Baltimore Gas and Electric. . . . Peggy's been taking self-improvement courses like career guidance, behavior modification for weight control, and assertiveness. The latter sounds like a prerequisite for aggressiveness, leading to a postgrade in obnoxiousness. Actually, it's 'appropriate behavior' — don't be bamboozled but don't be overpowering. Jack's biannual attack of insanity is a math class at Johns Hopkins. Contour integrals, zeta, beta, and gamma functions filled every evening before he dozed off between the Riemann sheets. That's over now and he can get back to the household chores again."

To which I add, best wishes to all. — **Frank T. Hulswit,** Secretary, Acorn Park, Cambridge, Mass. 02140

53

Dear Fellow '53ers: If you get tired of stale and slim news in issue after issue of *Technology Review,* then please direct your "fire" at the appropriate culprit. You may easily find him or her by simply standing in front of the nearest mirror. In brief, get on the horn and write me.

I made a quick trip to Los Angeles and Las Vegas in mid-April; gave a talk at the University of Southern California in which I debunked the gargantuan $9 billion rail transit proposal for Los Angeles and then hustled back to Pittsburgh via Las Vegas. Later this week I'll vacation for a week in Paris. So much for the rigors of academe.

David Berkowitz has been promoted to lead the Power Plant Dynamics and Control Group at MITRE Corp., where he has worked since leaving Bell Labs in 1961. Interestingly, David took a two-and-one-half year leave of absence and with his family became Peace Corps volunteers in Suva, Fiji. . . . **Everett Hobart** writes, "After ten years as Laboratory Director of Ledoux and Co., I have been appointed Technical Director of Spectrochem Laboratories in Franklin Lakes, N.J. My wife, Marianne, and I are parents of three sons and two daughters. Next fall we will have two in college, and it gets worse after that!" . . . From the newsclip pile: **Byron Atwood** has been elected to the Board of Directors of the Naumkeag Trust Co. in Salem, Mass. He is president of Atwood & Morrill Co. in Salem, the father of six children, married to Margaret Erskine, and lives in Marblehead.

Now the last of the Christmas card mail bag: Grayce and **Sid Hess** reported in. Sid resigned from the University of Pennsylvania; he's now (and has been for a while) Director of the Pharmaceuticals Planning and Development of ICI United States and finds his job both challenging and rewarding. He's active in T.I.M.S. (and was and/or is President) *and* the Girl Scouts. (How did you ever pull *that* off?) They have two daughters and a son; the eldest is a junior at the University of Delaware. . . . Virginia and **Paul Shepherd** sent along their Christmas letter, though Virginia did comment that "this is not the kind of letter we usually send our swinging bachelor friends." To attempt coverage of the "life and times" of their *six* (yep, you heard it) active youngsters — oh yes, and two parents — would be interesting but take more space than is allowed. Thus a quick look. Paul is still a very big wheel (my words) with Cabot, Cabot and Forbes, travels a lot, and is President of the National Association of Industrial Parks; Virginia (as she puts it) "presides over the complexities and fairly constant confusion while Paul is traveling, which is just about all the time," though they did sneak in a late 20th-anniversary trip to Hawaii and a swing around the east coast together. Their eldest (female) is a sophomore at Stanford; the next oldest is finishing his freshman year at Harvard; the other four range from the sixth to 11th grades. . . . Speaking of zillions of children, has anybody heard from our other "mass producer" team, Janie and **Gil Gardner**? . . . **Jim Howard** wrote that he, Dory, and three children are thoroughly enjoying life. He has been — for 13 years — a principal in Andruss-Peskin Corp., a manufacturers' representative firm which handles stress analysis products, instrumentation for some interesting applications, and specialty transducers. Their boy is a sophomore at Rensselaer Polytechnic Institute, and the two girls are in Wayland (Mass.) schools. Jim also is in an owner-operator partnership of a ski area (Saddleback Mountain, Rangeley, Maine) and "all skiers and non-skiers of the Class of '53 are invited to drop by."

Don't forget to write. — **Martin Wohl,** Secretary, 4520 Carriage Ln., Pittsburgh, Penn. 15221

54

John Griffiths, now a full Colonel, is Deputy Commander at the Air Force Technical Applications Center, Patrick A.F.B., Fla. John taught at the Air Force Academy for five years prior to his present assignment. . . . **Ted Slosek** has been appointed Manager of Marketing for the General Electric Company's Irradiation Processing Operation in California. . . . Also from California, **Bob Anslow** visited the Institute in April to initiate our 25th Reunion Gift planning.

David Wiesen, along with wife Muriel and 6-year-old Sloan, recently visited Romania with a side trip to Kiev, Russia. Sloan apparently did not enjoy the trip, but has been a hit with his friends at home with tales of Transylvania and Dracula's Castle. . . . **Philippe Dennery** is reportedly doing well with an interior construction business in Paris, France. . . . **Al McWhirter** and family are living in Fuerth, West Germany, where Al is coordinating manager of a cooperative arrangement between Combustion Engineering Power Systems and Kraftwerk Union. — **Dave Howes,** Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaries: **Chuck Masison,** 76 Spellman Rd., Westwood, Mass. 02090; **Lou Mahoney,** 6 Danby Rd., Stoneham, Mass. 02180

55

Is anything happening out there? News has been scarce, and we may indeed have to invent some interesting biographies. Who knows — perhaps the post of class secretary is the first stop on the road to literary greatness? (Allan knows.)

Sandy Goldman, Mary Glenn, and their children Abigail Hannah (7), Adam Max (5) and Rebecca Ruth (2) are still living in Bethany, Conn., population 3,300, in the middle of a dense forest. They live at an elevation of near 1,000 feet on a hilltop. Mary Glenn is attending Southern Connecticut State College for her masters in speech therapy, and is busy with school and home. About a year ago Sandy was appointed to head a new business venture of the Picker Corp., where he has been for almost eight years. Sandy was Director of Engineering for Nuclear Medicine and Diagnostic Ultrasound for almost six years, and has since been named general manager of Clinical Laboratory Products. While in engineering he picked up three patents in the field of nuclear medicine (an achievement which warms the cockles of your correspondent's heart). Now that he is an executive he just writes memos!

Sandy and Mary Glenn see Rita and **Bob Posner** fairly often, and have chatted with **Gene Davis** over the years. Sandy has almost given up flying and is considering joining the Long Island Sound set with a sailboat — "much slower, by about 10^{-2} — and cheaper by the same factor!" He would love to see anyone near New Haven.

Since I have not yet reached the novelist stage, I initiated a new program of stirring up old memories via the phone.

Dick Bergman is the executive vice president of Systemedics, Inc., a firm which furnishes computer services for physicians and has done considerable consulting for H.E.W., working with the National Health Service Corp. and with local communities to supply doctors to medically under-served areas. Dick was a co-founder of Systemedics and has been associated with the company since 1965. He also reports that his daughter Deborah is a possible poetess, having entered Barnard last fall at 16, while his other daughter Susan is in high school.

Bud Jacobs is at Boeing Computer Services, where he is the New York operations manager and new business development manager of the Education and Training Division. That division is the successor to Softwear Sciences Corp., in which Bud was a principal and which was acquired by Boeing in September, 1975. Bud, his wife Gerry, their daughter (14) and son (11) live in Port Washington, Long Island. Gerry is another candidate for a masters degree, currently completing her studies in library science.

By the time these notes reach printed form, your New York correspondent will have completed a business trip (on which my wife Devra and 15-, 12-, and 7-year-old children will be along to lend assistance) to Israel and Europe. Assuming that we make it back from the turbulent Middle East, I may bug others of you by phone to keep these articles coming. To avoid that terrible fate, let us hear from you! — Co-secretaries: **Marc S. Gross,** 3 Franklin Ct., Ardsley, N.Y. 10502; **Allan C. Schell,** 19 Wedgemere Ave., Winchester, Mass. 01890

61

In spite of statements made in the last class notes column there do seem to be some stirrings about a reunion. Shortly after I wrote the column, **Tom Hastings** took it upon himself to become the reunion committee and a mailing was dispatched. Response was quite good and a full scale get-together was organized. Since Tom was about to be married in California, it was a meritorious activity above and beyond the call of duty. I'll report about Tom's new wife and the reunion later this year.

Ken Blanchard writes: "after graduation, I went to Princeton for a Ph.D. in chemistry and then to teach at Vassar for three years. Naturally, I met my wife, Rita, the first year there. At this point I changed my mind and went to medical school, graduating from Cornell in 1972. Rita also got the bug, graduated from Cornell in 1974, and is now a resident at Tufts-New England Medical Center. I am now finally finishing my training at the Boston V.A. Hospital and will go into private practice (internal medicine and endocrinology-diabetes) at Newton-Wellesley Hospital this summer."

Every year about this time I get a note from **Avram Kalisky** telling me that he is Director of the National Physical Laboratory of Israel. This year he also mentions that he is a member of the Honorary Committee CPEM76 (whatever that is). Perhaps Avram met **Irwin Sobel** a couple of years ago when Irwin was teaching computer sciences at the Technion in Haifa, Israel, from 1971 to 1973. Now Irwin is back in the U.S., working in the Department of Biological Sciences at Columbia University and doing computer-aided micro-anatomy. Irwin holds a Ph.D. in electrical engineering from Stanford and is married to Ceevah Freedman of Durham, N.C.

Max Keck is a hard sciences renegade also. He works for the physics department at John Carroll University in Cleveland, but is working on studies relating to the visual detection of moving patterns. This year he will be visiting professor at Ohio State University in the department of physiological optics. . . . **Tom Kailath** writes that he was elected a Fellow of the Institute of Mathematical Statistics in 1975. That followed logically from his election as an I.E.E.E. Fellow back in 1970. He also served as president of the I.E.E.E. Information Theory Group in 1975.

Fred Salvucci, who is Massachusetts Secretary of Transportation, has been embroiled in the Concorde SST controversy since Boston is an emergency landing site of the plane. A lot of people want to keep it out of our skies. From the paper I have the impression that Fred would rather the plane didn't land in Boston, but that the decision may be out of local hands and in the jurisdiction of the F.A.A. We probably will be seeing the SST in town on an irregular basis for the next couple of years. . . . **John Reed,** who is an Executive Vice President of the First National City Bank of New York, is now on the Board of Directors at Phillip Morris, Inc. Our class is beginning to infiltrate the infrastructure of the establishment! . . . **Ken Hootnick** is General Manager of General Cable's Diamond Expansion Bolt Division. . . . Finally, Major **William Anderson** of the Air Force got his second Commendation Medal last year. He is with the 389th Tactical Fighter Squadron in Mountain Home, Idaho.

That's the file. More notes depend on you. Please write. It gets lonely here. — **Andrew Braun,** Secretary, 464 Heath St., Chestnut Hill, Mass. 02167

62

Gerald L. Katell has been elected to membership in the Young Presidents' Organization, Inc. (Y.P.O.), a worldwide educational association of more than 3,000 successful young chief executives who have become presidents of sizable companies before the age of 40. Y.P.O.'s purpose is to provide its members an exchange of education and ideas. — **Gerald L. Katell,** Secretary, 250 E. First St., Los Angeles, Calif. 90012

63

Marty Eisenberg's wife, Esther, wrote a newsy letter about her family's recent activities. (From my own experience I know that M.I.T. alumni are poor correspondents, so I'd like to encourage other spouses to write, too.) Marty and Esther are living in Holmdel, in central New Jersey, where Marty works for Bell Labs. They have two daughters, ages 7 and 10. The 10-year-old claims she is going to M.I.T. some day, but her parents are trying to discourage her. (Why?) In November, 1976, the family will attend the International Teletraffic Congress in Melbourne, Australia, and last November they went to an Operations Research Conference at the M.G.M. Grand Hotel in Las Vegas. They are sure they saw a few ex-M.I.T. students at the gambling tables figuring out the odds.

Jim Tang reports on a new addition to his family. Andrew R. Tang was born on Guam on November 29, 1975. Mother and child are both doing fine. . . . **Roger Weissinger** writes that he is finishing his Ph.D. work in "human problem solving" in an interdepartmental graduate program at Stanford University. . . . **Bruce Eisenstein** has won the C. Holmes MacDonald Award, presented to young educators for excellence in teaching, research and community service, from Eta Kappa Nu, the national electrical engineering honor society. Bruce lives with his wife, Toby, and two sons in Wyndmoor, Penn. After receiving his M.S.E.E. from Drexel, he was an instructor there from 1965 to 1971. In 1970, he received his Ph.D. from the University of Pennsylvania, and, since 1971 has been an Assistant Professor at Drexel. In 1970 he was a Fellow at Princeton.

Michael Feld has been appointed Director of the Spectroscopy Laboratory at M.I.T., succeeding Professor Richard Lord. Mike received his B.S. in 21-B, humanities, and then went on to get his M.S., and his Ph.D. (1967) in physics at M.I.T. He has been active in the field of laser physics and laser spectroscopy, especially the interaction of intense light fields with atomic and molecular systems. He has also done work in the biological applications of lasers and the history of science. Mike was a postdoctoral fellow at M.I.T. in 1967-68. He was appointed Assistant Professor of Physics in 1968, and Associate Professor in 1973.

Barbara and I had the pleasure of a visit from **Dick Males,** who was on the West Coast for an American Society of Civil Engineers meeting in San Diego. We saw some photos of Dick's son, Nathaniel, now 15-months-old. Dick is still living in Cincinnati with his wife, Barbara, and their older boy, Matthew. He passed along some information about a few of our less communicative brethren: **Sal Mazzotta** is chief of software systems for Le Messurier Associates in Cambridge. Sal and his wife Libby are living in Bedford, Mass., with their son Matthew. . . . **Bill Jessiman** has his own consulting firm, doing work primarily in the transportation field, and some jobs for E.R.D.A. He keeps in shape playing club hockey. . . . So much for this month. Let's have some letters. — **Mike Bertin,** Secretary, 18022 Gillman St., Irvine, Calif.

64

Greetings! Well, we did it — a month of *no* class heroes, and none of those friendly alumni fund envelopes came with the deadline notice.

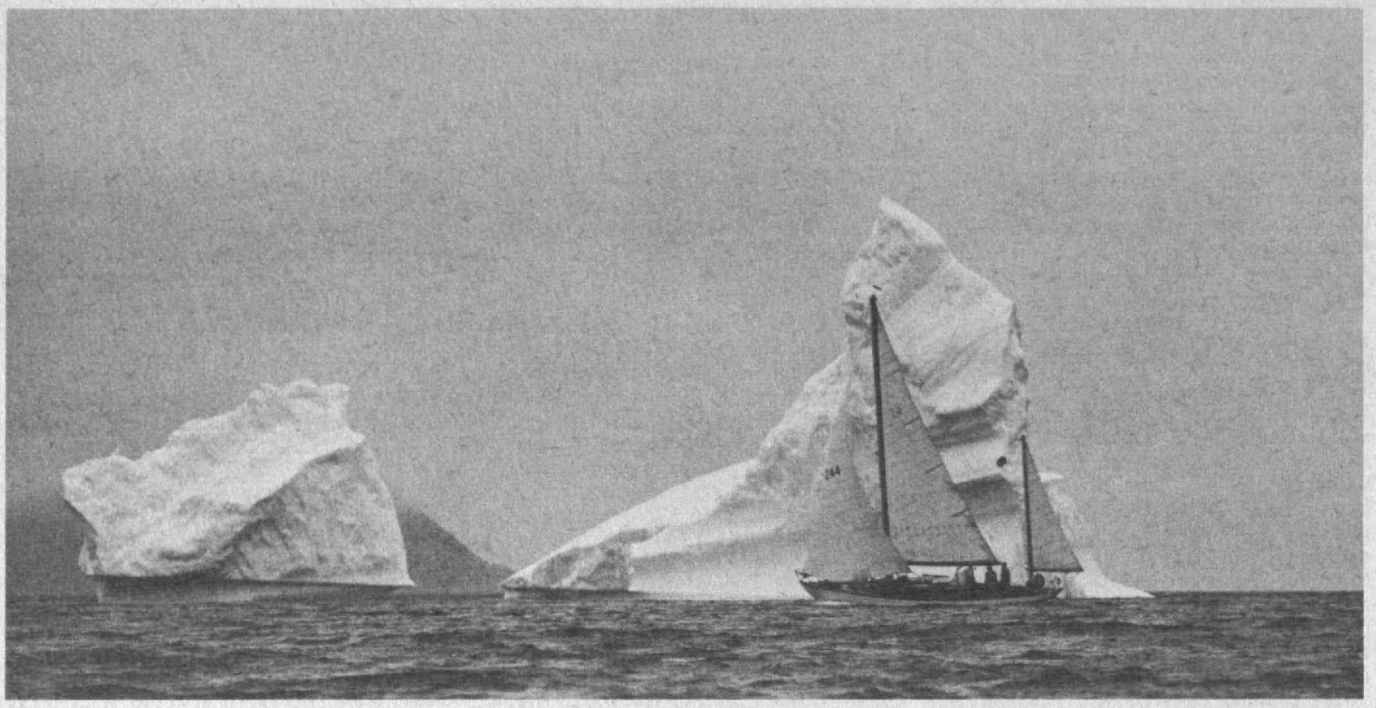
I spoke to **Don Torrieri** a few weeks ago. He and his wife, Nancy, have a new baby, Karen, their first. Don is working at N.R.L. (Naval Research Lab, Washington, D.C.) and the family residence is Silver Spring, Md. . . . **Gary Walpert** was in the area last week, on business at the U.S. Patent Office.

We had a nice spring holiday season, getting in some travel, a little vacation and a lot of sun. *Looking forward* to hearing from all of you. *Write,* please. — **Steve Schlosser,** Secretary, 12401 Bobbink Ct., Potomac, Md.

65

Peter Sexton's time in England was well spent: he acquired a Ph.D. and a bride, the former Anne Wilson of Birmingham, England. Peter is looking for a 1965 *Technique*; the Institute is all out. If any of you are about to throw one out, pass it on instead. . . . **Steven Maimon** has joined B.D.M. Corp. as Principal/Manager, dealing with "civil sector marketing and program management," both domestic and foreign.

Kenneth Brecher called the other day. Ken entered with our class though he graduated a year early; I assured him he could remain forever a member of our sterling ranks. Ken stayed at M.I.T. to earn his doctorate, spent three years as a postdoctoral fellow at the University of California in San Diego, and returned to M.I.T. in 1972 as Assistant Professor of Physics, specializing in astrophysics — specifically neutron stars. Ken's wife, Aviva, '68, is also an M.I.T. Ph.D. working on solid state astrophysics. The Brechers live in Belmont with daughter Karen, 6 months, and a collection of surrealist art.



Sailing Among Shapes of Ice

Many sail off the coast of Manchester, Mass., in early June, but few continue to the coast of Labrador where the summer sun glares off shapes of ice, and one hears the rain of melting ice and the hollow kawumph, kawumph of waves lapping under the edges of icebergs.

A fascination for the north and the desire to "spar with nature" led Steve Loutrel, '65, and his wife Lizzie to return to Labrador (where they had kayaked two years before) last summer in their 40-foot Concordia yawl *Lacerta.* Now an assistant professor of mechanical engineering at M.I.T., someday, Steve thinks, he'd like to do research on the arctic.

Over the three months and 4,000 miles of travel the crew members varied: Pete Richardson, '48, Director of Admissions at M.I.T., was aboard for part of the trip north; Virginia and Mike Adler, '65, and an archeologist from the Smithsonian Institute joined them for the northern-most journey; and they were accompanied homeward by Steve Leighton, who is presently studying at M.I.T. for a doctorate in bioengineering. To facilitate the rendezvous, George Foot, '67, set up an antenna on top of MacGregor House in Cambridge and Steve advised George of their progress every morning at 7:30 by amateur radio.

It was an obstacle course from beginning to end. One day out of Manchester, before anyone had gained his sealegs, a squall in the Gulf of Maine forced them to heave to for 24 hours. The jury-rigged self-steering arrangement proved successful enough to allow a retreat to their sleeping bags below where all succumbed to a bout of seasickness. Still a watch was stood every 15 minutes to ensure that all was in order on deck.

Dense fog and ice in the Strait of Belle Isle, was met with a sense of security as the result of a little mechanical ingenuity. Steve had set up a radar reflector before the trip, which made the boat look like a "small river tanker" on a radar screen. They had no problem claiming a wide berth from larger shipping vessels. "It's like making a VW look like a tractor trailer truck," Steve added whimsically.

After sailing up the costs of Nova Scotia and Newfoundland, they found little lightheaded sailing off Labrador. The waters were very poorly charted. (The existing charts were not detailed on water depths, islands were missing, and some islands shown on the charts didn't exist.) "We had to go very cautiously with someone up the mast much of the time watching for reefs and shoals."

But Steve found this uncertainty a challenge. "I didn't know if I could operate under those conditions, but I wanted to try it," Steve said; "I thought I could sharpen my senses that way." The trained observer can discover reefs by the breaks in the motion of the sea, and the characteristics of the cliffs at the shoreline frequently give clues about the underwater terrain, he explained.

One morning while anchored in Red Bay on the southern tip of Labrador, they were rudely awakened by a collision with an ice pan (a remnant of first-year ice, which rises about two feet above the surface and may stretch 500 feet). Though the Labrador coast is usually cleared of pack ice by August, ice pans and the various sized pieced of icebergs — growlers, bergy bits, brash — travel with the southward flow all summer.

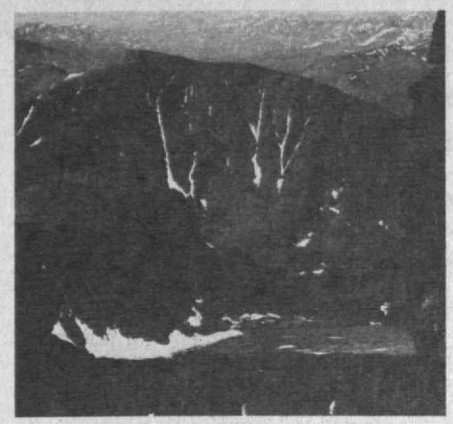
This new navigational hazard, if not more treacherous than the lack of adequate charts, was more nervewracking. "Occasionally we'd pass amongst the ice and then hear the pans grind together behind us."

One day they had managed 30 miles and only five miles remained to their harbor destination. "It was just a couple of hours before dark," Steve recalled. "Looking ahead from up the mast, it wasn't at all clear we could get through, and I got the nagging feeling that maybe this was the time we shouldn't have gone on. We decided on a route, and when things got tight we'd slow to a dead idle and drift up to the narrow opening, passing through with only inches on either side. Sometimes we were faced by impassable ice and then had to double back.

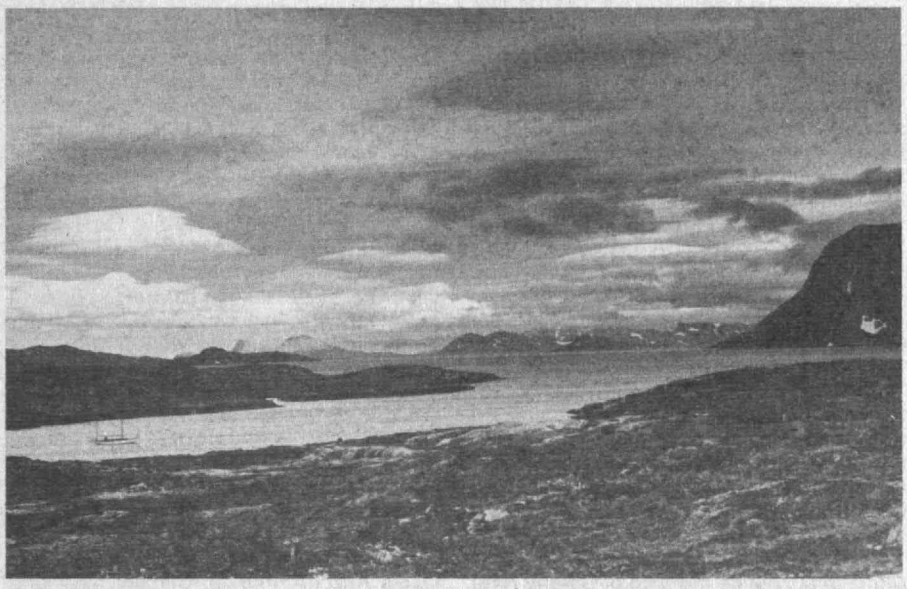
"Some of the time you feel scared, in a state of overawareness and the beauty and novelty of the ice all around makes it worth it. When we finally reached shelter there was a wonderful feeling of relief, much more so than after a full gale — then, at least, you know what's going to happen next."

When they arrived at the Eskimo settlements of Makkovik, Hopedale, and Nain, they found they were the first boat from the south, even before the coastal steamer made the first trip of the season. After Nain, the last settlement along the coast, they faced the stark mountains, called Torngats ("Home of Evil Spirits") by the Eskimos, and the possibility of 100-knot winds rushing down precipitous fiords. They were ashore in Nachvak Fiord to climb three 5,000-foot mountains, some previously unclimbed.

At their farthest north, O'Brien Harbor in the Northwest Territories, they rowed ashore and climbed to 700 feet to look under the cover of clouds toward the Button Islands, only 15 miles into Hudson Strait — where they hoped to visit. "With the close-packed ice eddying in the 7-knot current of Hudson Strait before us, it would have been suicidal to continue." — *S.F.*



Steve and Elizabeth Loutrel voyaged 4,000 miles in their yawl, the Lacerta *(far left), to the tip of Labrador last summer. After leaving Nain, the northernmost settlement on the coast, they discovered a terrain nurturant of only moss and lichen and the stark mountains called Torngats (below) by the Eskimos. In the Nachvak fiord area they climbed 5,000 feet to the summit of one of the many unnamed peaks (above). (Photos: Steve and Elizabeth Loutrel)*



The reason Bruno is so proud to be an honorary member of the class is that he is a dog school dropout. Bruno's only academic achievement of note is a second-place finish in the "pre-novice" competition; he got a perfect score in the long sit and the long down (no points were deducted for his falling asleep), and five points out of the remaining 110. I warned you what would happen if there were no Class news! Please write. — **Edward P. Hoffer, M.D.,** Secretary, 12 Upland Rd., Wellesley, Mass. 02181

67

John Schwarz writes: "I finished my residency in ophthalmology at Boston University in June, 1975, and presently am spending two years active duty under the Berry Plan in the Navy as the ophthalmologist at the Newport Naval Regional Medical Center. My wife Nancy and I have two children: Eric, 5, and Lauren, 2. We have a lovely ocean view here in Middletown, R.I., although we still own a home in Framingham, Mass., where we hope to return. I have a speedboat for waterskiing and fishing, and sing with the Newport Navy Choristers and with the 'Nautical Notes.' I get to Boston once a month for the meetings of the New England Ophthalmological Society. We would like to hear from **Mel Snyder, Gerry Siegel** and Rich Millman, '66." . . . **Joel Berk** has joined the faculty at the Columbia Graduate School of Business where he expects to earn his Ph.D. in Business within the next year or two. . . . **Jearl Walker** received his Ph.D. in Physics from University of Maryland in 1973 and is now Assistant Professor of Physics at Cleveland State University. He is the author of *The Flying Circus of Physics,* which was published in 1975 by John Wiley & Sons. . . . Susan and **Mark Grossman** and their children Jennifer and Jonathan are enjoying life in Princeton. Mark recently was promoted at RCA. . . . On May 8, **Jim Dotson** married Sarita Dhir of Richmond, Va., and formerly of New Delhi. Sarita teaches interior design at Virginia State College, and Jim is a chemical engineer with Columbia Nitrogen Corporation in Augusta, Ga., where they will live. . . . **G. Peter Grant** has been appointed Director of Corporate Budget and Accounting for Howmet Turbine Components Corp. in Muskegon, Mich. He previously worked with Howmet in Greenwich, Conn., and as an auditor with Goodyear International. . . . The Rev. **Max Polak** recently celebrated his First Solemn Mass in Springfield, Mass. He initiated his studies of theology in Rome and completed them in 1974 with a doctorate in sacred theology from the University of Navarre (Spain). Father Polak will be chaplain of Warrane College, a student residence at the New South Wales University campus in Sydney, Australia. — **Jim Swanson,** Secretary, 669 Glen Rd., Danville, Calif. 94526

69

Here it is primary season; I've been on the road finding out more than I could ever possibly want to know about the Presidential candidates.

Captain **Ronald L. Bagley** has received the U.S.A.F. Commendation Medal at

Malmstrom A.F.B., Mont., for meritorious achievement as a member of a special studies group with the 17th Defense Systems Evaluation Squadron, a unit of the Aerospace Defense Command. Ronald holds the aeronautical rating of navigator. . . . **Michael Ginzberg** finished his Ph.D. at Sloan in May. Mike married Rosemary Dunn (Wellesley 1970, Harvard Ph.D. 1975) in July, 1975. Mike began teaching at Columbia's Graduate School of Business in September, 1975 and has not had time to do anything else since. . . . **Ben Huie** is now working at the University of Arizona as a post-doctoral research associate on metal-nitrosyl chemistry. . . . **Eugene Lee** won First Year Honors at the Harvard Business School and is now in the second and final year of Harvard's M.B.A. program.

Larry L. Lowry is a management consultant with the Boston Consulting Group, Inc., in Menlo Park, Calif. . . . **Hans W. Polzer** is a First Lieutenant in the Army and stationed in Stuttgart, Germany. He is working as a systems engineer on a message processing system utilizing two PDP 11/45s. He recently married Audrey Boulden of Cecilton, Md., who is also working for the Army in Stuttgart.

During a hectic swing through New York City at the end of March during which I managed to catch the traveling roadshows of Messrs. Carter, Jackson, and Udall, I visited Howard Radin, '70, and his brother Michael, '72, at their plush East Side apartment/office. They've managed to cut commuting distances down to about 20 feet. . . . **Carol Scott-Connor** writes that she is "finally almost through with school." She'll be starting a general surgery residency in July, hopefully in New York City. . . . Assistant Professor of Electrical Engineering **Alan S. Willsky** has received the 12th Donald P. Eckman Award of the American Automatic Control Council. The award is presented to a researcher under the age of 30 for outstanding contributions to automatic control. Professor Willsky was cited for his work in estimation and control theory, algebraic system theory, the application of modern control theory concepts to problems in aerospace and biological systems, and for his outstanding performance as a teacher at M.I.T.

I am not sure who sent me a postcard from San Juan, Puerto Rico, but before I print the text I would appreciate knowing who sent it because the signature is indecipherable.

Have an enjoyable summer. — **Peter Peckarsky,** Secretary, 950 25th St., N.W., Washington, D.C. 20037

70

The March *Business Week* magazine cover story was written by **Karen Wattel Arenson.** The article focused on the nations's commodities markets. **Greg Arenson** passed the Illinois bar in October, 1975, and practices law with Rudnick and Wolfe in Chicago. He manages to touch nearly all areas of the law but criminal defense work. . . . **Susan Winard** has continued her success in the medical field and has started her residency in pediatrics at the Medical College of Pennsylvania, formerly named Women's Medical College. Susan noted that she had just finished her electives in pediatrics and an externship in psychiatry. In observance of the Bicentennial, she extends an invitation to all to visit her in Philadelphia. . . . **Ernest Gladney** relays a brief report on the birth of a daughter, Christine Dianne, in May. He enjoys the beautiful outdoors of the southwest. . . . **Frank Pompei,** it was recently announced by Scientific Engineering Systems, was promoted to manager of Thermal Systems after having been an engineer for several years. His responsibilities include coordinating research and engineering customer development, as well as other liaison activities.

Last year marked an active year for **Anthony Picardi.** First, he finished his Sc.D. in social-environmental systems at M.I.T. His thesis concerned problems of drought and famine in West Africa — the complex social and ecological aspects were reviewed in the March/April issue of the *Review*. Subsequently, Frank formed a consulting firm, Development Analysis Assoc., in Cambridge and has studied the water and power needs of Saudi Arabia. This study, of course, involved data collection for several months in that kingdom. Interspersed in this schedule, was a vacation trip to the West and the presentation of a paper in San Diego to a nutrition education convention by his spouse, Shirley, who received a Ph.D. in nutrition from M.I.T.

I have not been quite as active as the above alumni, but have been involved in some interesting litigation. My spouse, Maggie, who is also an attorney, and I attended a seminar in professional liability at the University of Michigan. We seem to spend most of our leisure time planting various types of trees in our yard and trying to start a garden. — **Robert Owen Vegeler,** Secretary, Kennerk, Dumas, Burke, and Backs, 2120 Fort Wayne National Bank Bldg., Fort Wayne, Ind. 46802

71

Clifton K. Chang writes: "I am managing the real estate sales and joint venture program of the Trammell Crow Co., a national real estate developer. Dallas is great — lots of money; but is somewhat deficient in Chinese restaurants and Chinese girls." . . .

John Stefano and his wife Karen are proud to announce the birth of Cyrena Ariel on February 10, 1976. John is finishing his medical internship this June, and starting his ophthalmology residency at Beth Israel Hospital, New York City.

Please write to inform the class of your activities. — **Hal Moorman,** Secretary, 3461 McFarlin, Dallas, Tex. 75205

72

If no news is good news, this has been the class of '72's finest month.

Herewith, the two items I have. **James Mosora** has completed a communications systems officer course and is assigned to Offutt A.F.B., Nebraska, with S.A.C. He received an M.S. from Purdue. . . . **Wendy Erb** writes, "I'm going to New York to work for a few years (or a few months depending on what I think of it) next fall. **Kathy Kram Dobkin** was up in Boston recently. She's doing very well at Yale. She saw **Arlene Fingeret** in Cambridge. I'm getting quite a sunburn, playing lots of tennis in this disgustingly nice California weather. **Gail Thurmond**'s planning on heading back to New England next year. **John Gunther** sounds very happy up in Alaska and ready to stay there at least a while longer." — **Dick Fletcher,** Secretary, 135 West St., Braintree, Mass. 02184

75

Michael A. Picheny, now a graduate student in Course VI, received the Eastman Kodak Fellowship for the 1975-76 academic year. . . . **Ralph A. Groemping** has been working for J. Watson Noah Associates, Inc., an economic consulting firm in Alexandria, Va., since September. He was appointed to assist in the derivation of cost estimating relationships for advanced aeronautical systems, and in the applications of this analysis to alternative government aeronautical programs. . . . **David L. Neuburger,** as of last September, began his medical studies at the Pennsylvania State University College of Medicine in Hershey, Penn.

John Hoffman is involved in cancer research at the University of Wisconsin's McArdel Laboratory. John has been admitted to the University of Wisconsin Medical School for the coming fall. . . . **Val M. Heinz,** now a graduate student in Course XVI, won first prize for his paper, "Analysis of a Space-based Fuel Station," presented at this year's American Institute of Aeronautics and Astronautics National Student Conference, in Washington, D.C. He was granted a Masters degree in Aeronautics and Astronautics this spring, and is beginning active duty in the Air Force.

Craig S. Hammes is in Medical School at the University of Iowa. He says, "I am enjoying it very much, though I'm already becoming impatient to begin my clinical years." . . . **John Eidinger** is doing work in structural engineering at Berkeley. He says that with today's job market, he "wishes he had listened to his mother and applied to medical school."

I heard from **Mark S. Hannig,** who is living in Palo Alto. He writes that after graduation last year, he ferried single engine aircraft (without radios) from factory to new owners and dealers. His travels took him as far as Arizona, Florida, Canada, and Minnesota. From July to September, he was a crop duster in Caldwell, Idaho. After a winter in Palo Alto as an aircraft mechanic (among other jobs), he'll be flying again this summer and fall out of Salmon, Idaho. He will be a "bush pilot, mainly flying river raft trips and hunters into the back country as well as some fire patrol and regular charter flying."

One final thing. I'd like to apologize to all of you who have sent me news in the past year but have never seen the column in which you were mentioned. As you all must know, there was a delay of several months before the class of '75 began receiving their *Review* subscriptions (even though I've been writing columns since last summer), and it's very likely that your news appeared in an earlier issue. If any of you are wondering why you were left out, I can assure you, you weren't. I receive too little news as it is. And if any of you would like to correct this situation, how about dropping me a line sometime to tell me how you're doing? — **Jennifer Gordon,** Secretary, 5 Centre St., Apt. 32, Cambridge, Mass. 02139

Use this coupon to send us your Tricentennial idea.

Send your idea to:
Tricentennial
Atlantic Richfield Company
P.O. Box 2076
Los Angeles, CA 90053

From: _____

Address _____

City _____ **State** _____ **Zip** _____

My idea is:

We have always been a nation more interested in the promise of the future than in the events of the past.

Here at Atlantic Richfield we see the future as an exciting time. The best of times. And we know that all of us can achieve a splendid future by planning for it now.

We'd like your help. We need your vision. America will change a great deal by the year 2076. We want you to tell us what you think those changes should be.

What do you envision as the best way to solve our energy problems?

Should we have a universal language?

How do you think architecture of the future can improve on that of the present?

Or, if those topics don't appeal to you, pick one that does.

Please note that all ideas submitted shall become public property without compensation and free of any restriction on use and disclosure.

ARCO

Petroleum Products of
AtlanticRichfieldCompany

Celebrate America's Tricentennial 100 years early.

We're up to our EER's in improvements!

Presenting McQuay's upgraded line of large air-cooled chillers and condensing units.

1. Improved Energy Efficiency Ratios (EER'S) provide more efficient cooling, lower operating costs.

2. Improved performance for bigger savings – new unloading method allows independent refrigerant circuits to share reduced loads, making less work for the compressor and reducing power consumption.

3. Increased coil-face area – boosts heat-exchange efficiency to help reduce overall operating costs.

4. Improved design flexibility – chiller capacity is now up to 130 tons, condensing units up to 160 tons. So you can use one unit to do the same job as multiple units and save on field labor costs. And the oversize condenser coil results in a lower (20° F) temperature difference, so ambient operating temperatures can be higher.

7. Improved total-package concept – Costs less to install than built-up units. Outdoor mounting means less wasted space – frees up indoor space for occupant use. Single point power connection saves electrical hook-up costs. Fully fused.

6. "Efficiency-Engineered" for less maintenance – solid-state timers for longer life, low replacement costs, better accuracy. All electrical controls and hookups are centralized at one end of the unit – plus much more!

5. McQUAY EXCLUSIVE! Controlled Override of Pump Shutdown (COPS™) on chillers allows a building's entire cooling system to be shutdown during unoccupied hours to save energy dollars. In addition, COPS maintains a recycling pump down sequence to prevent compressor slugging while providing chiller freeze up protection by allowing for override of the system pumps. This feature can really cut operating costs!

The bottom line is savings! The savings in operating costs can be very impressive with McQuay's efficient ALR/ALP units. In southern climates a 100 ton unit will save 65,500 KW-hrs. COPS™ time-clock control will save an additional 240 KW-hrs. in chilled-water pump operation *during a single weekend shutdown*. At 5¢ per KW-hrs. McQuay units will result in an annual savings of $3,659.

For full details, contact your McQuay HVAC representative now, or write to: McQuay-Perfex Inc., Box 1551, Minneapolis, MN 55440.

B. E. James
IX-B 1932
Chairman of the Board

J. B. Hoaglund
BSE 1945
President, McQuay Group

McQUAY GROUP
McQUAY-PERFEX INC.®